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Molecular Systematics and the Origins of Gypsophily in *Nama* L. (Boraginaceae)

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Molecular Systematics and the Origins of Gypsophily in *Nama* L. (Boraginaceae)

by

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Dedication

For my son Graeme, who reminds me to greet every day with an inquisitive mind and an open heart.

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obtained records of *Nama* collections from the REMIB database (Red Mundial de Información Sobre Biodiversidad; www.biosci.utexas.edu/prc/mexicanPlantDatabase.html) via the Plant Resources Center website, accessing the XAL, IEB, LL, TEX, and UNAM nodes.

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Molecular Systematics and the Origins of Gypsophily in *Nama* L. (Boraginaceae)

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Nama L. is a genus of approximately 50 species of herbs and subshrubs that occurs in habitats ranging from arid deserts to mesic woodlands in the New World and the Hawaiian Islands. The group has historically been divided into five or six subgeneric groups based on habitat as well as on the morphology of the anthers, styles, leaves and seeds. At least 14 species of *Nama* from the Chihuahuan Desert Region are either facultatively or obligately endemic to gypsum deposits. This dissertation examines interspecies relationships within *Nama* from a molecular phylogenetic perspective in order to evaluate historic morphology-based subgeneric classification systems of the genus and to examine the origins of facultative and obligate gypsophily within the genus. DNA sequence data from the chloroplast regions *mat*K and *ndhF* and from the nuclear ribosomal region ITS were collected from 46 species of *Nama* as well as from four new species and several outgroups. Data were analyzed using maximum likelihood and Bayesian methods. Phylogenetic analyses recover seven strongly supported major lineages within *Nama*. These lineages do not correspond to traditionally recognized subgenera, although they are largely congruent with an informal system based on ultrastructural observations of seeds. Four of the seven major lineages include gypsophilous species; these range from two lineages that include a single facultative gypsophile each, to one lineage that is almost entirely comprised of gypsophiles.

Gypsum endemism in general, as well as facultative and obligate gypsophily in particular, has arisen multiple times in *Nama*. Parametric bootstrapping rejected the hypothetical monophyly of gypsophiles across the genus as a whole and within each of the two clades that contain multiple gypsophiles. Because approximately 20 species have been described since the last major revision of *Nama* nearly 80 years ago, detailed morphological observations of herbarium specimens were made in order to produce a comprehensive key to the species of *Nama* as well as the revision of a lineage comprising eight gypsophiles and one limestone endemic.

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Chapter 1: Introduction

Nama L. is a New World genus in the Hydrophylloideae subfamily of Boraginaceae that encompasses approximately 50 species of annuals and perennials ranging in form from herbs to suffruticose or woody subshrubs. Leaf shape ranges from obovate to linear, and many species have villous to hispid vestiture covering leaves, stems and calyx lobes. The flowers are pentamerous, with funnelform to campanulate corollas that are usually pink, purple, or white in color, ranging in size from 3 – 12 mm across. The five anthers are adnate to the corolla for one-third to two-thirds of their length, typically unequal in length, often having winged margins along the adnate portion of the stamens. Members of the Hydrophylloideae differ from other borages in having capsular fruits rather than nutlets or drupes, and bifid rather than fused styles. Two morphological characters separate *Nama* from other hydrophylls: none of the species have scorpioid inflorescences, instead bearing single or paired flowers or simple or compound cymes, and in all cases the leaf margins are entire rather than toothed or divided.

Almost 40% of the species within *Nama* are desert plants; the genus has been found in all North American deserts, as well as the Monte desert of Argentina and coastal deserts of Chile and Peru. The center of diversity of the genus covers north-central Mexico and the southwestern United States; outside of this region, the genus extends northward along the west coast of the United States, eastward along the coast of the Gulf of Mexico (including the Caribbean Islands), and southward to montane regions of southern Mexico and Guatemala. Three species are amphitropically disjunct, occurring in both North and South America. One species, *Nama sandwicensis* A. Gray, is endemic to the Hawaiian Islands.

Many distinctive endemic species and species-rich communities have evolved on gypsum deposits, especially in the north-central region of Mexico, where gypsum deposits have been exposed for a longer period than at higher latitudes (Powell and Turner 1977). Four species of *Nama* have been collected exclusively from gypsum deposits in the Chihuahuan Desert Region (*N. canescens* C.L. Hitchc., *N. carnosa* (Wooton) C.L. Hitchc., *N. stenophylla* A. Gray ex Hemsl, and *N. stevensii* C.L. Hitchc.); a further 10 species grow on both gypsum and limestone-rich substrates. A group of seven species that comprises obligate and facultative gypsophiles, as well as one species that apparently only grows on limestone outcrops, has evolved a distinctive morphology that separates it from the remainder of the genus. In contrast to the decumbent, spreading or ascending habit and the ovate, oblanceolate, or elliptic non-succulent leaves that are characteristic of the rest of *Nama*, these species consist of erect, tall plants (up to 60 cm) with long, linear leaves that are succulent and terete. The remaining gypsophilous species in the genus are either similar to non-gypsophiles or intermediate between the two morphological types, for example, bearing leaves that are ovate or elliptic but also succulent (e.g., *Nama havardii* A. Gray), or having a decumbent form and nearly linear leaves (i.e., *N. stevensii* C.L. Hitchc.).

The most recent monographic work treating *Nama* is Hitchcock's excellent taxonomic study (Hitchcock 1933a, b, 1939), which recognized five sections based on morphological features such as style fusion and ovary position. Earlier work (Brand 1913) had utilized those characters, as well as the proportion of the anther filament that is adnate to the corolla (less than one-third or greater than one-half) to delimit subgenera. More recently, ultrastructural features of the seeds of *Nama* were examined in an effort to describe natural groups within the genus (Chance and Bacon 1984).

This dissertation examines the evolutionary history of *Nama* from a molecular phylogenetic perspective in order to elucidate interspecies relationships with respect to the morphological characters that delimit traditional subgeneric groups and to assess the origins of gypsophily within the genus. Sequence data were collected from 90 accessions, which included 80 ingroup accessions representing 50 species of *Nama* as well as 10 outgroup taxa. Two chloroplast markers, *mat*K (including the 5' and 3' *trn*K introns; Johnson and Soltis 1994, Steele and Vilgays 1994, Kelchner 2002) and *ndh*F (Olmstead and Sweere 1994) were selected, as was the nuclear ribosomal marker ITS (Baldwin et al. 1995).

Chapter 2 reconstructs the molecular phylogeny of *Nama* and investigates the correspondence of three morphological characters historically employed to delimit subgeneric groups - style fusion, stamen morphology, and ultrastructural seed features – to the relationships reconstructed from the chloroplast and ITS data sets. Prior molecular work (Ferguson 1998a) demonstrated that two of the monotypic sections recognized by Hitchcock (1933; *Arachnoidea* Peter and *Cinerescentia* Peter) were more closely related to the borage genus *Eriodictyon* Benth. than to *Nama*, so these sections were not considered. Subgenus (or section) *Conanthus* S. Watson has traditionally included species with connate styles, although the number of species included in the group has fluctuated between seven (Brand 1913) and two (Jepson 1925, Hitchcock 1933a) due to a confusing application of the "fused styles" criterion. For example, *Nama stenocarpa* A. Gray was included in subgenus *Conanthus* by Brand (1913) but segregated into the monotypic section *Zonolacus* (Jeps.) C.L. Hitchc. by Hitchcock (1933) by virtue of its purported semi-inferior ovary. Brand (1913) divided subgenus *Marilaunidium* Kuntze (which included species with completely bifid styles) into sections *Paleonama* Brand and *Neonama* Brand based on anther filament adnation, assigning 20 species to the former group (with the free portion of anther filaments longer than the adnate portion) and 10 species to the latter (free portion of anther filaments shorter than the adnate portion). More recently, Chance and Bacon (1984) divided 37 species of *Nama* into six informal "seed groups" based on variations in seed coat ultrastructure, describing putative evolutionary relationships within and between the groups. In order to examine the potential correspondence of seed coat character states to monophyletic groups within *Nama*, scanning electron micrographs were obtained for eleven species that were not included in Chance and Bacon's (1984) study to provide a more complete data set of seed coat characters. Reconstruction of a molecular phylogeny provides an opportunity to evaluate whether any of the characters that were historically used to delineate subgeneric groups are synapomorphies for natural groups within *Nama* or whether they are the result of convergent evolution. The molecular phylogeny also allows examination of the geographic origin of *Nama sandwicense*, the Hawaiian Islands endemic, through identification of its closest relatives.

Chapter 3 examines the evolution of gypsophily within *Nama* using molecular phylogenetic methods. While the distinctive floral assemblages found on gypsum soils in the Chihuahuan Desert have attracted attention since the mid-20th century (Johnston 1941a, Waterfall 1946; Shields 1956; Parsons 1976; Henrickson 1976; Turner and Powell 1977; Powell and Turner 1979; Bacon 1981), much remains unknown about these communities (Meyer 1986, Meyer et al. 1992, Escudero et al. 1999, Palacio et al. 2007). Gypsum outcrop "islands" occur intermittently across the desert landscape, ranging in size from less than 100 square meters to over 100 square kilometers (Powell and Turner 1977, Shields 1956); gene flow between outcrops is reliant upon long-distance dispersal. With 14 out of 52 species exhibiting a preference for gypsum in the Chihuahuan Desert Region ranging from facultative to obligate gyposphily, *Nama* is an excellent model system for exploring the evolution of gypsum endemism. The gypsophilous species include both widespread (*Nama stenophylla* A. Gray ex Hemsl.) and narrowly distributed (*N. hitchcockii* J.D. Bacon) species. The well-supported chloroplast and ITS phylogenies reconstructed in Chapter 2 provide a backbone for exploration of various hypotheses addressing the origins of gypsophily within this diverse group. Both nonparametric and parametric statistical tests, as well as ancestral state reconstruction, were used to evaluate explicit hypotheses regarding the origins of gypsum endemism in *Nama*. From these analyses we could determine whether or not gypsophily was restricted to a single lineage, ascertain a credible number of origins of gypsum endemism within *Nama*, and examine the relationships between obligate and facultative gypsophiles.

Chapter 4 provides a diagnostic key to all species of *Nama* as well as a revision of the species of a single clade of Chihuahuan Desert gypsophiles recovered by analyses of the chloroplast and ITS datasets in Chapter 2 (the *Nama stenophylla* lineage). Since the most recent monographic work on *Nama* (Hitchcock 1933a, 1933b) occurred nearly 80 years ago, an additional 20 species have been described with no single resource available to aid in the identification of all species. A comprehensive key will be most helpful to botanists, ecologists, and other scientists working in regions where *Nama* grows. Detailed morphological observations for the key were obtained from 394 herbarium specimens and field observations. The species treated in the revision of the *Nama stenophylla* lineage are not only interesting for their peculiar substrate preference, but important from a conservation standpoint. Gypsum mining is an important industry in Mexico, and few gypsum-rich areas outside of the Bolson de Cuatro Cienegas in Coahuila are protected. Examination of 297 herbarium specimens and field observations from 5 trips to the Chihuahuan Desert led to the recognition of nine species in this group, including a new species, *Nama "jimulco"* (in prep) from the Sierra de Jimulco in eastern

Coahuila, Mexico. The revision includes synonymy, description, phenology, ecological observations, geographic distribution, and a short discussion for each species. Maps were produced for each taxon in this clade based on field observations and data gathered from herbarium labels.

Chapter 2: Molecular phylogeny of the genus *Nama* (Boraginaceae) and correlation to historic morphology-based infrageneric classification systems

INTRODUCTION

Nama L. is a genus of 52 species and 18 varieties (Table 2.1) in subfamily Hydrophylloideae of the Boraginaceae. With the most recent APG system, the limits of Boraginaceae are circumscribed broadly and the family is unassigned to any order, although its placement in the euasterid I (lamiids) clade is well supported (APG III 2009). Prior to APG I (1998), the genera that are now within subfamily Hydrophylloideae made up the family Hydrophyllaceae R. Br., of which *Nama* was the second-largest genus. Molecular evidence indicated that neither Boraginaceae nor Hydrophyllaceae was monophyletic as traditionally circumscribed. However, the genera of Hydrophyllaceae, excluding *Hydrolea* L. and *Codon* L., formed a clade nested within Boraginaceae (Ferguson 1998b, Olmstead and Ferguson 2001).

The geographical distribution of *Nama* is restricted to the New World, with the majority of species found in low-elevation deserts and arid regions (Figure 2.1). The center of diversity of the genus is located in the southwestern United States and north-central Mexico, with approximately 38% of the species diversity occurring in the Mojave, Sonoran, and Chihuahuan deserts. At least 12 desert species are reportedly either facultatively or obligately endemic to gypsum deposits; the evolution of these endemics will be discussed in Chapter 3. Within *Nama*, three species (*Nama undulata*, *N. dichotoma*, and *N. jamaicensis*) have disjunct distributions between North America (the United States, Mexico, and in the case of *N. jamaicensis*, the Caribbean Islands and northern parts of Central America) and South America (Argentina, Chile, Ecuador, Peru, and Bolivia). Amphitropical disjunctions in New World taxa are a commonly observed pattern, with long-distance dispersal most convincingly implicated as a mechanism of migration particularly for infraspecific disjunctions (Raven 1963; Carlquist 1967; Peterson and Morrone 1997; Peterson and Ortíz-Diaz 1998; Simpson et al. 2005). *Nama dichotoma* and *N. undulata* each have one variety with a disjunct distribution and one variety endemic to South America. Given that the vast majority of species in this genus occur only in North America, it is most possible that the South American populations of *Nama* are a result of several long-distance dispersals from North America. There is no evidence to date that would indicate that speciation within *Nama* has taken place in South America, although the presence of endemic varieties suggests that genetic differentiation is almost certainly occurring there.

In addition to South America, *Nama* has dispersed to the Hawaiian Islands. *Nama sandwicensis* is endemic to the atoll and is the only hydrophyll that is native there. This distributional pattern of amphitropical disjunction plus dispersal to Pacific islands has been observed in several genera representing a variety of families (e.g., *Lepidium* (Brassicaceae), *Aster* (Asteraceae), *Carex* (Cyperaceae), *Rubus* (Rosaceae), *Viola* (Violaceae), and *Sanicula* (Apiaceae)), with dispersal to the Hawaiian Islands generally proposed to be from North American or boreal areas (Carlquist 1967; Vargas et al. 1998). to explain the presence of the genus in Hawaii, Carlquist (1967) postulated a single introduction of *Nama* by birds via mechanical attachment of fruits to feathers. Endemism is particularly high among Pacific island species that were ostensibly dispersed by birds, presumably because of the rarity of such a phenomenon (Carlquist 1967). The evolutionary relationships between the Hawaiian and mainland species of *Nama* are of particular interest.

Linnaeus (1759) described *Nama jamaicensis*, which is now the conserved type species of *Nama* (Vahl transferred *N. zeylanica*, which was the first *Nama* described by

Linnaeus in 1753, to *Hydrolea* in 1791; this ultimately led to a period of nomenclatural confusion described in Chapter 4). Early taxonomic work on *Nama* spanned the mid-19th to early 20th centuries, resulting in the description of 15 species by 1882 (Choisy 1833, 1846, Gray 1861, 1870, 1875, 1882; summarized in Hitchcock 1933a). Beginning in 1913, the genus underwent several revisions (Brand 1913; Jepson 1925 [treating just the California taxa]; Hitchcock 1933a, Hitchcock 1933b, Hitchcock 1939), leading to the recognition of 37 species and several subgeneric classification systems (Table 2.2). In the 78 years since Hitchcock's monograph, which is the most recent comprehensive, systematic treatment of the genus, approximately 20 additional species have been described.

The morphological characteristics that have primarily been used to separate the species of *Nama* into subgeneric groups are the degree of style fusion, ovary position, and proportion of the stamen that is adnate to the corolla. Brand (1913), Jepson (1925), and Hitchcock (1933a) all recognized subgenus or section *Conanthus*, diagnosed by the presence of connate styles. This seemingly straightforward criterion has been rather inconsistently applied over the last century: of the seven species included by Brand (1913), Jepson (1925) and Hitchcock (1933) retained only two (*Nama densa* and *N. aretioides*), reassigning the rest to other subgenera or sections. One of those species, *N. stenocarpa*, has connate styles but was segregated (as subgenus or section *Zonolacus*) based on its inferior ovary. Of the remaining species, one (*N. humifusum*) was reduced to synonymy, one (*N. stenophylla*) has styles that are free to the base, and two (*N. spathulata* and *N. biflora*) have styles that are united, albeit only halfway. Furthermore, Hitchcock (1933b) noted that another species, *N. jamaicensis*, has styles that are often united up to half of their length and that in fruit the calyx hardens and adheres to the capsule, giving the appearance of an inferior ovary. Yet he did not assign it to either section *Conanthus* or section *Zonolacus*.

More recently, Chance and Bacon (1984) examined SEM images of the seed coats of 37 species of *Nama* to investigate variation within the genus and to examine whether observed patterns in seed coats correlated to Hitchcock's (1933a) subgeneric classification system. The 37 species were divided among six informal "seed groups" based on seed coat morphology (Table 2.3) and putative evolutionary relationships within and between the groups were described. With the intent to assess whether these informal seed groups were compatible with evolutionary relationships inferred from molecular data, we used scanning electron microscopy to examine the seeds of twelve species that were not included in the Chance and Bacon (1984) study to provide a more complete data set of seed coat characters. Reconstruction of a molecular phylogeny provided an opportunity to evaluate whether any of the characters that were historically used to delineate subgeneric groups are synapomorphies for natural groups within *Nama*, or whether they are the result of convergent evolution.

To date, only one published study has utilized molecular data for *Nama*. Eleven species of *Nama* were sampled for a molecular phylogeny of Hydrophyllaceae inferred from both chloroplast (*ndh*F) and nuclear ribosomal (ITS) DNA (Ferguson 1998a, 1998b). That study provided molecular evidence that the genus is paraphyletic, with nine of the sampled species forming a monophyletic group and the other two sampled species (*Nama rothrockii* and *N. lobbii*) more closely related to *Eriodictyon*.

In order to investigate the processes that shaped the current biogeography and evolutionary history of *Nama*, a robust phylogeny of the genus was reconstructed based on independent molecular data sets. This phylogeny provided a platform on which hypotheses addressing subgeneric organization and biogeographic origins within the genus might be tested. Specifically, we evaluated whether historically recognized subgenera comprising multiple species formed monophyletic groups; whether the ultrastructural similarities uniting the informal seed groups of Chance and Bacon (1984) corresponded to specific evolutionary lineages, and the whether the origins of the Hawaiian endemic, *Nama sandwicensis,* could be confidently identified.

MATERIALS AND METHODS

Taxon sampling and outgroup selection

Nomenclature followed that of Hitchcock (1933a, 1933b, 1939), who conducted the most recent major revision of the genus, and included all subsequent validly described species with the following exceptions:

- *Nama dichondrifolia* Standl. was excluded because we consider this species to be a synonym of *N. propinqua* C.V. Morton & C.L. Hitchcock. The designated types of each name are morphologically indistinguishable and were collected from locations approximately 32 km apart in Mpio. Muzquiz, Coahuila, within two weeks of each other in 1936. Comparison of representative, non-type DNA sequences obtained for molecular phylogenetic analysis revealed virtually no differences between specimens originally determined to be *N. dichondrifolia* and *N. propinqua*; the ITS sequences were separated by 1 base pair, while the *ndh*F and *mat*K sequences were identical. The name *N. propinqua* was validly published before *N. dichondrifolia* and has priority.
- *Nama berlandieri* A. Gray was included despite Hitchcock's (1933b) reduction of the species to synonymy with *N. undulata* var. *macrantha* Choisy. Billie Turner (pers. comm.) suggested that the taxon may merit specific status based on style

length and geographic distribution. Preliminary analyses of DNA data supported the inclusion of *N. berlandieri* as a speces distinct from *N. undulata*.

- *Nama rothrockii* A. Gray and *N. lobbii* A. Gray (=*Eriodictyon lobbii* (A. Gray) Greene) were included with outgroup taxa based on a phylogeny of the Hydrophyllaceae inferred via analysis of ITS and *ndh*F sequences (Ferguson 1998a, 1998b). These species had long been recognized as morphological oddities within *Nama*; Peter (1897) segregated each in monotypic sections (*Cinerescentia* and *Arachnoidea*, respectively), and Hitchcock noted the similarity of *N. lobbii* to species within *Eriodictyon*. The inclusion of these two species within *Nama* was precarious based on morphological observations, and molecular evidence confirmed that they were indeed more closely related to other genera. The placement of *N. rothrockii* within the *Hydrophylloideae* is uncertain, however, it is clear that *N. lobbii* properly belongs in the genus *Eriodictyon*; for the remainder of this paper, it will be referred to as *Eriodictyon lobbii*.
- While examining the collection of *Nama* specimens at TEX, we encountered three folders of specimens that had been set aside by B.L. Turner (2 folders) and J.D. Bacon (1 folder) and assigned herbarium names. In addition, we have discovered another putative new species. The names of these four entities have thus far not been validly published. The unpublished herbarium names are: *N. "baconii*," *N. "monclova*," *N. "whalenii*," and *N. "jimulco."* They were included in the molecular phylogeny but use of the names is not meant to constitute publication.

DNA was successfully isolated from specimens representing 46 of the 52 recognized species as well as from vouchers of the 4 putative undescribed species (Table 2.4). We were unable to obtain DNA from *Nama ehrenbergii*, *N. linearis*, *N. orizabensis*, *N. rotundifolia*, *N. rzedowskii*, or *N. segetalis*. Of these six species, *N. ehrenbergii, N.*

linearis, N. orizabensis, and *N. rzedowskii* are known only from types and were unable to be located in the field during multiple collecting trips for this project. The only known collection of *N. ehrenbergii* is the holotype, collected in 1837 by C.A. Ehrenberg (*Ehrenberg* 960) in San Sebastian, Mexico and deposited at the Berlin herbarium. Ehrenberg was a prolific collector in the region of Mineral del Monte (Dicht and Luthy 2005) so, of the eight towns named San Sebastian in Mexico (Roji Garcia and Roji Garcia 2006), this likely refers to a town in southwestern Hidalgo. The holotype appears to have been lost; there is no record of it at B or at HAL, the other herbarium that received specimens from Ehrenberg's collections. No photographs of the specimen have been located. *Nama segetalis* was described after taxon sampling for the project had been completed and material was not available. The original specimen of *N. rotundifolia* sampled for this study was incorrectly determined and subsequent attempts to isolate DNA from confidently determined *N. rotundifolia* samples failed.

The outgroup sampling strategy targeted taxa from each of the two main lineages within the "core Hydrophyllaceae" *sensu* Ferguson (1998a). Clade I outgroup taxa comprised *Emmenanthe penduliflora* Benth., *Phacelia congesta* Hook., *P. rotundifolia* Torr. ex S. Watson, and *Tricardia watsonii* Torr. ex S. Watson. Outgroup taxa from Clade II (which includes *Nama*; Ferguson 1998a, 1998b) were *Eriodictyon californica* Greene , *E. crassifolium* Benth., *E. trichocalyx* A. Heller, *E. lobbii* Greene, *"Nama" rothrockii* A. Gray, *Turricula parryi* J.F. Macbr., and *Wigandia urens* Urb. var. *caracasana* (Kunth) D.N. Gibson. Preliminary analyses led to the exclusion of more distantly-related hydrophylls (*Codon* L. spp. and *Hydrolea* L. spp.) and closely related borages (*Ehretia* P. Browne) from the outgroup because of alignment challenges.

Tissue collection, DNA extraction, marker selection, amplification and sequencing

DNA was extracted from herbarium specimens with permission from TEX and NY and from silica-dried field-collected material using the standard CTAB protocol (Doyle and Dickson 1987) or a QIAGEN DNEasy ® Plant Mini Kit (QIAGEN). A set of three criteria was considered for evaluation of candidate molecular markers. The first requirement was a rate of sequence divergence adequate to resolve relationships between species. Secondly, we assessed the ease of amplification and sequencing. The third criterion was whether the candidate marker had been used in previous studies of related taxa; this could facilitate the future placement of results from this study within a broader context. Chloroplast regions *mat*K (Johnson and Soltis 1994, Steele and Vilgays 1994, Kelchner 2002), *ndh*F (Olmstead and Sweere 1994), and *trn*L-*trn*F (Taberlet et al. 1991), and nuclear markers ITS (Baldwin et al. 1995, Alvarez and Wendel 2003) and *waxy* (GBSSI; Mason-Gamer et al. 1998) were considered. Of these, *mat*K, *ndh*F, and ITS best met the three criteria and were selected for sequencing.

The chloroplast gene *ndh*F (Fig. 2.2) is located in the small single-copy region of the chloroplast genome and encodes a subunit of chloroplast NADH dehydrogenase (Kim and Jansen 1995; Olmstead and Reeves, 1995). Previous studies demonstrated its utility in reconstructing relationships at various taxonomic levels, including at the species level and within Boraginaceae (Ferguson 1998a, Ferguson1998b, Park et al. 2001, Moore and Jansen 2006, McDill et al. 2009); both universal and hydrophyll-specific primers (Ferguson 1998a, Olmstead and Sweere 1994) were readily available. The region was amplified in 3 overlapping sections and sequenced using 7 sequencing primers (Figure 2.2; Table 2.5).

The *mat*K gene encodes a maturase that splices introns from RNA transcripts and is located entirely within an intron of the *trn*K gene in the large single-copy region of the chloroplast genome (Soltis and Soltis 1998). The region that was selected for this study includes the entire coding region of *mat*K, a portion of the 5’ *trn*K intron and the entire 3’ *trn*K intron (Fig. 2.3). In *Nama*, approximately 12% of the region that was amplified and sequenced for this project consists of rapidly-evolving non-coding DNA. The marker was previously used to resolve species-level relationships within *Tiquilia* (Boraginaceae; Moore 2005), as well as within the “core Hydrophyllaceae” (Ferguson 1998a, 1998b). Universal primers were available (Johnson and Soltis 1995, Sang et al. 1997), and preliminary work indicated that amplification and sequencing of the region were straightforward. This region was amplified in 2 or 3 overlapping segments and sequenced using 7 to 9 primers (Figure 2.3; Table 2.5).

The internal transcribed spacer (ITS) region was selected to provide information from a second genome, thereby avoiding potential weaknesses of single-genome phylogenies (Soltis and Soltis 1998). The ITS region consists of three components (ITS-1, 5.8S nrDNA, and ITS-2) located between the 18S nrDNA and the 26S nrDNA (Figure 2.4) repeated in tandem array, resulting in thousands of copies per cell. The 5.8S subunit is highly conserved, which simplifies alignment of multiple sequences and the identification of ITS-1 and ITS-2 borders. The ITS region has been used to reconstruct phylogenies across the angiosperms (Baldwin et al. 1995, Alvarez and Wendel 2003, Feliner and Rossello 2007) as well as in algae and ferns (Soltis and Soltis 1998). Furthermore, it has previously been used to investigate relationships within groups reasonably closely related to *Nama*, specifically among genera in the Hydrophyllaceae (Ferguson 1998a, 1998b) and to resolve interspecific relationships within *Tiquilia* (Boraginaceae; Moore 2005, Moore and Jansen 2006).

The ITS region is easily amplified because of its small size (600-700 bp across the angiosperms; Soltis and Soltis 1998), highly-conserved flanking regions which permit wide applicability of universal primers, and the presence of many thousands of copies per cell. However, the same qualities that make ITS attractive in phylogenetic investigations are potentially disadvantageous as well. The small size of the region limits the amount of information available, and because primer sequences are located in highly conserved regions, amplification and sequencing non-target ITS sequences (i.e., contaminants) is common. Finally, the presence of many thousands of ITS repeats within each cell may result in the amplification and sequencing of so-called pseudogenes (nonfunctional copies of ITS) or, if concerted evolution has not homogenized ITS within a species, multiple copies of ITS from a single DNA sample (Feliner and Rossello 2007). While these factors may complicate phylogenetic analyses, approaches such as identification of putative pseudogenes can minimize their effects. This region was amplified in one section (Figure 2.4, Table 2.5), and all PCR products were cloned as described below prior to sequencing.

The selected DNA regions (*mat*K, *ndh*F, and ITS) were amplified using a standard PCR mix consisting of 10-100 ng of template DNA, 2.50 μL of 10X buffer, 2.50 μL of 25 mM $MgCl_2$, 2.00 μL of 10mM dNTPs, 0.25 μL of 20 mM primer (x2), 1 unit of Taq polymerase, and enough ddH_2O to bring the total volume to 25 μL. When reactions utilizing this recipe failed, up to 1.25 μL DMSO and/or 2.00 μL BSA were added to the master mix with concomitant decreases in the amount of ddH_2O utilized to maintain a reaction volume of 25 μL. Several thermocycler programs were utilized during PCR based on the target DNA sequence (Appendix A).

Prior to sequencing, all PCR products were verified and quantified using agarose gel electrophoresis and a low mass ladder (Invitrogen). PCR products were cleaned using

Qiaquick columns (QIAGEN) or using an ExoSAP protocol (Werle et al. 1994), adding 0.2 mL exonuclease I (New England Biolabs) and 0.4 mL of Shrimp Alkaline Phosphatase (Promega) to 23 μL of PCR product. Tubes were incubated at 37 °C for 30 minutes followed by 15 minutes at 80 °C. Cleaned PCR products were prepared for bidirectional sequencing by mixing original amplification primers or a sequencing primer (1 primer per cycle sequencing reaction), Big Dye™ fluorescent dye-terminator reagent mix (Perkin-Elmer), and 20-40 ng of cleaned PCR product. The cycle sequencing protocol is described in Appendix A (program name TERMIN8). After cycle sequencing, samples were cleaned using Centri-Sep columns (Princeton Separation, Inc.) packed with G-50 Sephadex in preparation for sequencing on an MJ Research BaseStation automated sequencer. Alternatively, 20-40 ng of cleaned PCR products were combined with 0.5 μL of one sequencing primer and enough ddH_2O to bring the total sample volume to 12 μL and sent to the Institute for Cellular and Molecular Biology (ICMB) DNA Sequencing Facility at the University of Texas at Austin for cycle sequencing and subsequent automated sequencing by ICMB DNA Core Facility staff using ABI 3730 or ABI 3730XL DNA Analyzers.

While examination of preliminary sequencing results of ITS did not reveal the presence of multiple copies of the region (not shown), subsequent sequencing results uncovered evidence that most ITS sequences obtained directly from PCR products were indeed polymorphic. Consequently, immediately upon completion of the PCR and gel electrophoresis verification of PCR products, samples were cloned using a TOPO TA Cloning kit with pCR(R)2.1-TOPO(R) vector and One Shot (R) TOP10 Chemically Competent *E. coli* (Invitrogen). Cloning reactions were performed at one-third strength and incubated at 37 °C overnight. PCR amplification of ITS from at least ten colonies of transformed cells was accomplished using the same master mix of reagents as the original

ITS PCR but substituting M13F and M13R primers, which anneal to *E.coli* genomic sequence outside the boundaries of the ITS insertion. Thermocycler program CLONE (Appendix A) was utilized to amplify cloned ITS sequences. Sample cleaning and sequencing was as described above. With few exceptions, at least five clones per DNA accession were sequenced bidirectionally.

Raw sequence data were imported into Sequencher v.4.5 (Gene Codes Corporation, Ann Arbor, MI), assembled into contigs, and visually inspected for sequence ambiguities. Initial alignments of *mat*K and *ndh*F sequences were performed with ClustalX (Thompson et al. 1997). Alignments were manually adjusted in MacClade 4.08 (Maddison and Maddison 2000). Initial alignment of ITS sequences was performed with MUSCLE (Edgar 2004) and further manually adjusted using MacClade 4.08. The ITS matrix was searched for short nucleotide sequences within each clone that were indicative of functional ITS copies (Harpke and Peterson 2008) and pruned clones lacking those indicator sequences (i.e., putative “pseudogenes”) from the data set prior to phylogenetic analysis. Nine accessions were represented by fewer than 5 clones: *Nama californica*-202 (3 clones), *N. jamaicensis*-115 (4 clones), *N. schaffneri*-116 (4 clones), *N. havardii*-203 (4 clones), *Emmenanthe penduliflora*-181 (1 clone), *Eriodictyon crassifolium*-182 (4 clones), and *Tricardia watsonii*-179 (3 clones). *Nama depressa* and *N. havardii*-204 were represented in the chloroplast data set but excluded from the ITS data set because we were not able to obtain uncontaminated ITS sequences for them.

The Incongruence Length Difference test (Farris et al. 1994), which assesses whether characters comprising distinct data partitions are drawn randomly from a single pool of characters that reflects one set of evolutionary processes and one phylogeny, was employed to assess whether the *mat*K, *ndh*F, and ITS data sets were significantly heterogeneous with respect to each other, and thus, whether they could reasonably be combined for a single analysis. We tested *ndh*F vs. *mat*K, chloroplast (*mat*K + *ndh*F) vs. ITS, *mat*K vs. ITS, and *ndh*F vs. ITS. In all cases, results of the ILD test (implemented in PAUP* v.4b10 [Swofford 2003] as the partition homogeneity test) suggested that there was significant incongruence among partitions ($p = 0.01$). Aside from identifying heterogeneity between data sets, a finding of incongruence (i.e., rejection of the null hypothesis that two data sets are drawn from the same set of characters) may be obtained when one data partition is much longer than another; when one data partition is much noisier than another; or when among-site rate variation differs between partitions (Hipp et al. 2004). These factors could conceivably have impacted the outcome of the ILD tests of the above partitions, especially between chloroplast markers and ITS. For example, the chloroplast data set (4624 bp) is seven times longer than the ITS data set (760 bp) and much less noisy. Additionally, statistical tests of heterogeneity (including the ILD test) cannot distinguish between cases in which incongruent clades are only weakly supported and alternatives are only marginally better, cases in which different topologies reconstructed from independent data sets are strongly supported, or instances of stochastic variation between data sets with identical evolutionary histories (Johnson and Soltis 1998). For these reasons, we opted to analyze the chloroplast and ITS data sets separately as well as in combination.

Three alignments were produced for phylogenetic analysis. The chloroplast data set concatenated *mat*K and *ndh*F sequences for 80 accessions and was 3930 base pairs in aligned length. The ITS data set included 355 clones and was 694 base pairs in aligned length. The chloroplast and ITS data sets were combined by arbitrarily selecting a single cloned ITS sequence to represent each accession and concatenating that with the corresponding chloroplast sequence.

Phylogenetic analyses

All analyses were run on a Mac G5 with two 3-GHz Quad-Core Intel Xeon processors running a MacOSX 10.4.11 operating system, on the National Science Foundation's Teragrid accessed through the CIPRES Science Portal (www.phylo.org; Miller et al. 2010), or on a Dell Studio XPS 9100 with an Intel® Core TM 17 CPU processor running Windows 7. Each data set was analyzed under maximum likelihood (ML) and Bayesian optimality criteria. MrModeltest v.2.3 (Nylander 2004) was used to select the most appropriate model of evolution for each data partition (Table 2.6). The chloroplast data set was partitioned into "*mat*K noncoding" (i.e., the portions of the 5' and 3' *trn*K introns that were sequenced on either side of the *mat*K coding region), "*mat*K coding," "*ndh*F noncoding," (i.e., the portion of spacer that precedes the *ndh*F coding region), and "*ndh*F coding." The ITS data set was divided into "18S," "ITS-1," "5.8S," "ITS-2," and "25S" partitions. A summary of missing data is provided in Table 2.7.

Maximum likelihood searches using RAxML 7.2.8 (Stamatakis 2006; Stamatakis et al. 2008) were performed on partitioned data sets for the chloroplast and ITS. RAxML analyses were run on the CIPRES cluster, which automatically implements a general time reversible model with gamma distribution of rate heterogeneity for each partition. For each analysis, 10 replicate searches were performed to maximize the chance of finding the best-scoring ML tree at least twice. Each replicate included a full ML search utilizing parameter estimation and fast bootstrap searches. Half of the replicates for each data set (i.e., 5 replicates) were run on CIPRES's Blackbox server; bootstrap searches on Blackbox were terminated automatically when a majority rule threshold was met. For chloroplast searches, 200-250 bootstrap replicates were performed before termination. For ITS searches, 600-650 bootstrap replicates were performed before termination. The remaining 5 replicates for each (chloroplast and ITS) data set were run on CIPRES's XSEDE server, which performed 1000 bootstrap replicates for each search iteration. As a result, we obtained a total of 10 ML trees and 6100 bootstrap trees for the chloroplast data set and 10 ML trees and 8100 bootstrap trees for the ITS data set.

Maximum likelihood searches were also performed for the unpartitioned chloroplast, ITS, and combined data sets using GARLI v1.0 (Zwickl 2006). Ten replicate searches using default program settings were performed for the chloroplast and combined data sets; 20 replicate searches were performed for the ITS data set. We performed 1000 bootstrap replicates for each data set.

Bayesian analyses were conducted for the chloroplast, ITS, and combined data sets using MrBayes (Huelsenbeck and Ronquist 2001, Ronquist and Huelsenbeck 2003), implementing the models of evolution selected by MrModeltest. Analyses with paired runs were run for 5 million generations, at which point cold chain scores were graphed in Excel and output treefiles were examined using AWTY (Wilgenbusch et al. 2004) to assess whether the two runs had converged; if not, then analyses were run in further increments of 1 million generations until convergence had been reached. Analysis of the chloroplast data set did not converge by 20 million generations using the default cold chain temperature or 0.2, so the analysis was terminated and subsequently rerun with the cold chain temperature adjusted to 0.15.

Hypothesis Testing

Evaluation of specific topological hypotheses was carried out using the Approximately Unbiased (AU) test (Shimodaira 2002), the SOWH test (Swofford et al. 1996; Goldman et al. 2000), and, in a Bayesian framework, by calculating the proportion of post-stationarity trees that were consistent with each given hypothesis. Specifically, we tested whether observed differences in tree topologies that were recovered from different data sets (i.e., chloroplast vs. ITS vs. combined cp + ITS topologies) were significant, and whether the monophyly of informal seed groups (Chance and Bacon 1984), were compatible with the best trees obtained through maximum likelihood analyses (Figure 2.5). All SOWH tests were performed using GARLI set up to run in batch mode. Preliminary tests of the performance of GARLI and PAUP* running SOWH tests on identical data sets indicated that GARLI would return the same results as PAUP* but in a much faster time frame.

The SOWH test utilizes parametric bootstrapping to generate a distribution of d-scores (the difference in log likelihood scores of trees obtained through paired unconstrained and constrained ML searches) to which the observed difference between log likelihood scores of unconstrained and constrained ML searches using the chloroplast or ITS datasets is compared (Swofford et al. 1996, Goldman et al. 2000). Using GARLI, we found the best-scoring ML tree for each constraint (i.e., each hypothesis) using both the chloroplast and the ITS data sets. SeqGen (Rambaut and Grassly 1997) was used to simulate 100 replicate datasets based on the best-scoring ML constraint tree and the model parameters for that tree as reported by GARLI. Paired maximum likelihood searches were performed on each replicated data set to find the best-scoring unconstrained ML tree and the best-scoring ML tree under the constraint. The differences in log likelihood scores between the resulting trees formed the distribution against which we could compare the observed difference between the best-scoring ML tree obtained from analysis of the chloroplast or ITS data and the best-scoring ML tree under the constraint. Given a significance level (α) of 0.05, the SOWH test rejects a given hypothesis if the observed difference in log likelihood scores between unconstrained and constrained trees is larger than 95% of the d-scores in the distribution.

The Bayesian posterior probability of each hypothesis was obtained by loading post-stationarity trees from the chloroplast (20000 trees) or ITS (5070 trees) generated by MrBayes into PAUP* and filtering each set of trees with the constraint trees representing each hypothesis. The set of trees retained by the filter includes all post-stationarity trees that are congruent with the constraint tree. This proportion of trees (trees retained by the filter / all post-stationary trees) is the posterior probability of the constraint tree.

Seed Morphology

Three to five mature seeds of each species to be examined were obtained from herbarium sheets with permission from TEX; voucher information is provided in Table 2.8. Cross sections were prepared by slicing seeds in half using a sharp razor blade. Whole seeds and cross sections were adhered to stubs using SPI-Chem carbon suspension (SPI Supplies, West Chester, PA). Samples were sputter coated with a platinum-palladium mix to a thickness of 25 nm using a Cressington 208 Benchtop Sputter Coater at the ICMB Microscopy and Imaging Facility at The University of Texas at Austin. Seed images were obtained using a Zeiss Supra 40 VP Scanning Electron Microscope with voltage of 2 kV and working distance of 9-10 mm or voltage of 5 kV and working distance of 16-26 mm to produce images of 232-3970X magnification. Measurements of seed features in micrographs were obtained using Carnoy 2.0 (Schols and Smets 2001), a software package for measuring features in image files. Length and width of seeds were measured from images of whole seeds. Testa thickness was measured from images of seeds in cross-section.

RESULTS

Maximum likelihood and Bayesian analyses of each data set (chloroplast, ITS, and the combined chloroplast + ITS data sets) recovered the same set of seven major lineages (Table 2.9) although the relationships among clades varied by data set and analysis method (Figure 2.6). One species, *Nama stenocarpa*, was affiliated with different clades depending on data set and analysis type and was listed as "unasssigned" in Table 2.9. All analyses of the chloroplast data set placed *N. stenocarpa* sister to the *Nama serpylloides clade*, with moderate to strong support (BP=81, PP=0.91; Figure 2.6). Analyses of the ITS data set placed *N. stenocarpa* sister to the *Nama jamaicensis* clade; this relationship has high Bayesian support (PP=0.91) but very weak bootstrap support (BP=55). Analyses of the combined chloroplast and ITS data set placed *N. stenocarpa* sister to the *Nama serpylloides* plus *Nama hispida* clades, with strong support (BP=99 PP=0.99).

Nama densa lineage

The *Nama densa* clade encompassed seven species and was strongly supported across all analyses (BP=100, PP=1.00; Figures 2.7 – 2.9, Table 2.9). Within this clade, all analyses recovered a sister relationship between *Nama californica* and *N. demissa* (BP=92 – 100, PP=1.0; Figures 2.7 – 2.9), and all recovered a strongly supported clade of *N. aretioides*, *N. densa*, and *N. parviflora* (BP = 100, PP=1.0); however, species relationships within that clade varied by data set and analysis. The chloroplast data set reconstructed a grade with *N. parviflora* at the base, followed by *N. aretioides*, which was sister to the two *N. densa* accessions (Figure 2.7). The combined data set likewise resulted in a grade with *N. parviflora* at the base, followed by *N. densa*-129, followed by *N. aretioides* and another *N. densa* accession (*N. densa*-207), which were sister to each other (Figure 2.9). Finally, all analyses of the ITS data set suggested that *N. aretioides* was sister to *N. densa*-129; the relationships of the other taxa (*N. densa*-207, *N. parviflora*) did not agree among ITS analyses, however, bootstrap and PP values were weak (<60 BP/<0.6 PP; Figure 2.8). Analyses of the chloroplast and combined data sets placed *N. depressa* sister to *N. californica* + *N. demissa* (Figure 2.7 – 2.9); unfortunately, cloned ITS sequences from *N. depressa* were contaminated and not able to be included in analyses of the ITS data set.

***Nama stenophylla* lineage**

The *Nama stenophylla* clade comprised nine species (Table 2.9) endemic to gypsum and limestone deposits in the Chihuahuan Desert. Chloroplast and combined cp and ITS data sets yielded strong support for the monophyly of this group (BP=100, PP=1.0; Figure 2.9); support values from ITS data sets were lower (BP=62, PP=1.0). Within the group, all analyses agreed that *N. canescens* was sister to *N. hitchcockii* (BP=81 – 100 BP, PP=1.0; Figures 2.7, 2.9, and 2.10). Other relationships within the *Nama stenophylla* clade were less clear. Analyses of the chloroplast and combined data sets indicated a sister relationship between *N. stenophylla* and *N. flavescens* (BP=56 – 88, PP=1.00; Figures 2.7 and 2.9), however, analyses of the ITS data set did not recover a monophyletic group of *N. flavescens* clones and those clones did not appear to be closely related to *N. stenophylla*, grouping instead with a clade of clones sequenced from *N. johnstonii*, with less than 50% bootstrap or PP support (Figure 2.10).

***Nama jamaicensis* lineage**

Support for the monophyly of the *Nama jamaicensis* clade, a group of nine species (Table 2.9), ranged from weak to strong depending on data set and optimality criterion (Figure 2.6). Analyses of the chloroplast data set and the combined chloroplast and ITS data set exhibited very strong support clade (BP=100, PP=1.0). Maximum likelihood analyses of the ITS data set, however, yielded weaker support for the clade, with bootstrap support at 81% but PP=1.0. *N. stenocarpa* sister to the *jamaicensis* clade, though this relationship was essentially unsupported statistically except in the Bayesian results (BP=55, PP=0.91).

Interspecies relationships within the *Nama jamaicensis* clade were in general poorly supported in all analyses, although the results obtained from each data set were generally congruent (Figures 2.6 – 2.8). The best trees from each analysis depicted two subclades within the group: a clade of *N. marshii* and *N. propinqua* sister to each other, and a clade comprising *N. bartletii*, *N. biflora*, *N. hintoniora*, *N. schaffneri*, *N. palmeri*, *N. spathulata*, and *N. jamaicensis*. The subclade containing *N. marshii* was strongly supported in all analyses (BP=96-100, PP=1.0; Figures 2.7, 2.9, 2.11).

The subclade containing *Nama biflora* was likewise strongly supported in all analyses (BP=93 – 94 , PP=1.0; Figures 2.7, 2.9, 2.11) except for maximum likelihood analyses of the ITS data set, which measured less than 50% bootstrap support or posterior probability for this group. Relationships within the subclade were generally poorly supported, and even those with moderate to high support were incongruent between data sets. For example, all analyses of the chloroplast data set recovered a grade with *N. jamaicensis* at the base, followed by *N. palmeri*, which was sister to a group of the remaining species in the subclade (Figure 2.7). In contrast, the combined chloroplast and ITS data set also recovered a grade with *N. jamaicensis* at the base, however, the next species in the grade was *N. spathulata*, which was sister to a clade of the remaining species (Figure 2.9), whereas the corresponding grade in the ITS phylogeny had *N. spathulata* at the base, follwed by *N. jamaicensis*. Within the subclade, the clones of *N. bartletti, N. biflora*, *N. jamaicensis*, and *N. spatulatum* formed strongly supported monophyletic groups. The clones of *N. schaffneri* and *N. palmeri* did not form monophyletic groups. Interestingly, the clones of *N. hintoniora*, which were obtained from a single plant, formed two distinct, strongly supported monophyletic groups within the *Nama jamaicensis* clade

***Nama serpylloides* lineage**

The *Nama serpylloides* lineage was a moderately to strongly supported (87-100 BP/1.00 PP; Figure 2.6) group of six taxa: *N. serpylloides* var. *velutina*, *N. serpylloides* var. *serpylloides*, *N. cuatrocienegensis*, *N. torynophylla*, *N. parvifolia*, and *N. rzedowskii* (Table 2.9). Placement of *N. rzedowskii* in the *Nama serpylloides* clade was hypothetical and based on its phyllotaxy (Bacon 1981, Chance and Bacon 1984), as we were not able to obtain genetic material of *N. rzedowskii*. Most of the species in the *Nama serpylloides* clade are notable for having phyllotaxy that is distinct from the rest of the genus. Of the species in this clade, *N. serpylloides*, *N. cuatrocienegensis*, and *N. rzedowskii* always have opposite leaves from the bases to the apices of the branches. *Nama parvifolia* consistently has opposite leaves towards branch tips and alternate leaves towards branch bases. *Nama torynophylla* generally has alternate leaves throughout, although it resembles the other species in the group in leaf shape and size.

All analyses reconstructed a relationship between *Nama serpylloides* and *N. cuatrocienegensis* (Figures 2.7, 2.9, and 2.12). The ITS data set yielded a clade of *N. serpylloides* clones nested within essentially a polytomy of *N. cuatrocienegensis* clones; within this group of *N. serpylloides* sequences, clones obtained from the two varieties that we sampled (var. *serpylloides* and var. *velutina*) were intermixed (Figure 2.12). The combined chloroplast and ITS data set yielded a topology that was inconsistent with this arrangement (Figure 2.9): maximum likelihood analyses reconstructed a polytomy of two *N. serpylloides* var. *serpylloides* accessions and *N. cuatrocienegensis* that was sister to *N.*

serpylloides var. *velutina* (i.e., *N. cuatrocienegensis* was nested within several *N. serpylloides* sequences).

Species within this group are likely very closely related, as interspecies relationships were incongruent between the chloroplast and ITS phylogenies and few branches have any statistical support in either tree. In the chloroplast phylogeny, *Nama stenocarpa* was sister to this clade with moderate bootstrap support and strong Bayesian posterior probability (BP=81, PP=1.0; Figure 2.7). However, in the ITS phylogeny, *N. stenocarpa* was resolved as the sister of the *N. jamaicensis* lineage.

Nama hispida **lineage**

Ten species (including one undescribed putative species, *Nama "monclova"*) formed the *Nama hispida* clade (Table 2.9). Overall, analyses of the chloroplast data set yielded higher bootstrap and Bayesian support for relationships within this group than analyses of ITS and the combined chloroplast and ITS data sets (Figures 2.7, 2.9, and 2.13). Support for the monophyly of this group ranged from highly supported (BP=100 and PP=1.0 in the chloroplast phylogeny) to unsupported (BP<50 for ML analyses of the ITS data set). Relationships among species in this clade were generally well supported when reconstructed using chloroplast data, although the sequences of several accessions of *N. hispida* were scattered throughout the clade and did not form a monophyletic group (Figure 2.7). There was less support for relationships in the ITS tree, and those branches that did have significant bootstrap support or Bayesian posterior probabilities were not congruent with the chloroplast tree (Figure 2.13). _Analyses of the ITS data set recovered a clade of intermixed clones of *Nama sandwicensis* and *N. berlandieri* (Figure 2.13). The branch uniting these two species was weakly to moderately supported (BP=60, pp=0.99).

Chloroplast data and combined data sets that placed *N. sandwicensis* in a grade between *N. undulata* and *N. hispida* var. *sonorae* (Figures 2.7 and 2.9).

In the chloroplast and the combined analyses, *Nama hispida* var. *sonorae* was moderately to strongly supported to be sister to a clade of seven other taxa: *N. coulteri*, *N. turneri*, *N. hispida*, *N. "monclova," N. stevensii*, *N. retrorsa*, and *N. xylopoda* (Figures 2.7 and 2.9). Bootstrap support for the monophyly of these 7 taxa ranged from 78 – 81% (PP=1.0) and PP=1.0; bootstrap support values for *N. hispida* var. *sonorae* plus the 8 species ranged from 59 – 61%, with posterior probability less than 0.5. All ITS analyses reconstructed a basal polytomy for the *Nama hispida clade* that included a clade of *N. hispida* var. *sonorae* clones, a clade of *N. undulata* clones, and a clade of all the remaining taxa in the *N. hispida* group (Figure 2.13). All analyses recovered a close relationship of *N. "monclova"* and *N. stevensii* (BP=57 – 87,PP=0.99 – 1.0).

***Nama dichotoma* lineage**

Nine taxa made up the *Nama dichotoma* clade, including two putative new species *Nama "baconii*" and *N. "whalenii*" (Table 2.9). The other seven taxa in this group were *N. pueblensis*, *N. pringlei*, *N. origanifolia*, *N. sericea*, and three varieties of *N. dichotoma*: var. *dichotoma*, var. *latifolium*, and var. *chasmogama*. Branches within this clade were far longer than those across the rest of the phylogeny, regardless of data set or analysis (Appendix A). The chloroplast and combined analyses suggested that the taxa in this group formed a strongly supported monophyletic group (BP=94 – 100, PP=0.98 – 1.0; Figure 2.6); however, ML bootstrap analyses of the ITS was weak (BP=0.52).

Within the *Nama dichotoma* clade, all analyses recovered a strongly supported subclade comprising *Nama" baconii*," *N. "whalenii*," *N. pringlei*, and *N. pueblensis*

(BP=88 – 100, PP=1.00; Figures 2.7, 2.9, 2.14), with congruent topologies in all cases. Chloroplast and both combined chloroplast and ITS data sets recovered a sister relationship of *N. pringlei* and *N. pueblensis* (Figures 2.7 and 2.9), while ITS-only analyses showed all clones of *N. pringlei* and *N. pueblensis* intermixed into one strongly-supported monophyletic group (BP=98, PP=1.0; Figure 2.14).

The monophyly of *N. dichotoma*, which comprised three varieties, was confirmed by all analyses (90-100 BP/1.00 PP). Analyses of the ITS data set revealed that within *N. dichotoma*, clones of each variety formed reciprocally monophyletic groups. Placement of the remaining two species in the *Nama dichotoma* clade, *N. origanifolia* and *N. sericea*, varied by data set and analysis (Figures 2.7, 2.9, 2.14). Analyses of the ITS data set and of the combined chloroplast and ITS data set grouped these two species into a monophyletic group. There was moderate support for this arrangement in the ITS data set (81 BP/1.00 PP; Figure 2.14) but although the clade was recovered in the best-scoring ML trees of the combined data sets, there was <50% bootstrap support or posterior probability. Analyses of the chloroplast data set as well as for the partitioned chloroplast and ITS data sets yielded a grade with *N. sericea* at the base, followed by *N. origanifolia* sister to the *N. pringlei* subclade (Figure 2.7).

Nama hirsuta **lineage**

This clade was strongly supported by all analyses (BP=100 and PP=1.00; Figure 2.6; Table 2.9). The combined chloroplast and ITS data set recovered a strongly supported sister relationship between *N. hirsuta* and *N. quiexobrana*, which together were strongly supported to be sister to *N. prostrata* (94 – 99 BP/1.00 PP; Figures 2.7 and 2.9). In contrast, the partitioned analysis of ITS performed by RAxML recovered a topology that *N. quiexobrana* sister to *N. prostrata*. Support for *N. hirsuta*+ *N. quiexobrana* was low

(BP=65, PP=0.94; Figure 2.15). The clones of each species in this lineage formed strongly supported monophyletic groups.

Seed morphology

SEM images of seeds were compared to micrographs and seed group descriptions from Chance and Bacon (1984). Dimensions of seeds that we examined for this study are provided in Table 2.7, and representative micrographs are presented in figures 2.16 – 2.18. Criteria for assigning samples to particular seed groups were based on observations of the testa (seed coat) surface and cross-section as set out by Chance and Bacon (1984; Table 2.3). Seed groups 1 and 2 were characterized by a solid testa (observable in cross section) and differentiated by thickness (45 – 60 mm for group 1 and 2 –5 mm for group 2) and surface pattern (honeycombed for group 1 and foveolate for group 2). The remaining four seed groups had testas that were chambered in cross-section and that appeared reticulate or occasionally foveolate on the surface. Differentiating between these four groups relied on the appearance of the seed coat surface, particularly the radial walls of the reticulum cells, and underlying features of the seed coat chambers. Radial walls that were perforated and that have bumps or knobs adorning the concave apices characterized seed group 3. Seeds belonging to group 4 had localized thickenings along the radial walls. Seed group 5 was characterized by distinctive U-shaped thickenings that proceeded from one radial wall, across the floor of the reticulum, and up the opposite radial wall; the upper margins of the radial walls were also knobby. Group 6 seeds encompassed a broad spectrum of characters (Chance and Bacon [1984] were ambivalent about the cohesion of this group) but were united by the presence of undulate reticulum walls.

None of the seeds examined for this study were characteristic of seed group 1. *Nama berlandieri* (Figure 2.16 A and B) was observed to have a solid testa 3 –5 um thick and a foveolate surface and was placed in seed group 2. Cross sections of seeds were not examined for *N. coulteri* (Figure 2.16 C and D) or *N. xylopoda* (Figure 2.16 E), however, the surfaces of these seeds were foveolate and lacked any adornments such as pits, ridges, or knobs and closely resembled micrographs of seed group 2 species in Chance and Bacon (1984).

Seeds of two species, *Nama biflora* and *N. spathulatum*, were placed in seed group 3. The radial walls of seeds of both species were concave. The apices of the radial walls in the seeds of *N. biflora* were knobby, as is characteristic of that group (Figure 2.16 F and G). *Nama spathulata* seeds did not appear to have knobs, but the tops of the radial walls were ridged (Figure 2.16H).

Seeds from plants that were determined to be *Nama stewartii* was placed in seed group 4 based on its reticulate surface and bumpy radial walls (Figure 2.17A); these "bumps" on the lateral (not apical) surface of the walls may be the "localized thickenings" described by Chance and Bacon (1984). The micrograph of *N. stewartii* seeds closely resembled the micrograph of a seed of N. *havardii* published by Chance and Bacon (1984), which they likewise placed in seed group 4. We do not consider *N. stewartii* to be a distinct species, rather, the molecular phylogeny in conjuction with morphological observations made for Chapter 4 suggest that *N. stewartii* and *N. havardii* should be considered to be synonymous.

Two species exhibited the knobby upper radial wall margin and U-shaped cross-reticulum thickenings characteristic of seed group 5: *Nama cuatrocienegensis* and *N. quiexobrana*. The traits were very clearly observed for the seeds of *N. cuatrocienegensis* (Figure 2.17 B and C) but were less evident for *N. quiexobrana*. The seeds of *N.*

quiexobrana may have been immature or malformed – despite appearing normal under a dissecting scope, under the higher magnification of the SEM they appeared to have peculiar scales attached to the seed coat that were not observed on any other seeds in this study or reported by Chance and Bacon (1984) (Figure 2.17 D – F). There was one small patch on the seed where the scales had perhaps abscised and the seed surface below was reticulate; both the scales and the reticulum cells had very subtle U-shape thickenings.

The seeds of the remaining three species that were examined more or less fit the criterion of undulate radial walls for seed group 6. *Nama californica* had a chambered testa; reticulum cell walls were flat at the apex and lacked knobs or other thickenings and were barely undulate (Figure 2.18 A, B, C). The seeds of *N. pringlei* had a reticulate surface, with undulate reticulum cell walls (Figure 2.18 D and E). The apex of the reticulum cell walls was slightly concave, which is characteristic of seed group 3, however, the seed coat did not display any of the other features of that group (knobby wall apices, pits or perforations in the radial walls). *Nama pueblensis* seeds proved challenging to evaluate due to silt-like accretions on the seed coat that obscured the view of the testa surface (Figure 2.18 F and G). These accretions were observed on the seeds of both herbarium specimens that were sampled; the two specimens were collected several years apart and the odd surface is unexplained. Each seed did have a small "clean" area on the surface where the reticulum walls were observed to be undulate, suggesting placement in seed group 6.

DISCUSSION

Phylogenetic relationships within *Nama*

To summarize the results detailed in the previous section, phylogenetic analyses of the chloroplast, ITS, and combined data sets all recover an identical set of seven clades within *Nama*, although each data set yields a different topology with respect to the relationships among these major clades (Figure 2.6). Hypothesis testing confirmed that in most cases, the topological incongruence among data sets was significant (Tables 2.10 – 2.12). Evaluation of the chloroplast data set resulted in rejection of the hypothesis representing the combined chloroplast + ITS topology (SOWH $p < 0.05$; PP=0; Table 2.10); the hypothesis representing the ITS topology was not tested because all branches of the chloroplast phylogeny were very strongly supported by ML and Bayesian analyses, and it therefore seemed highly unlikely that the null hypothesis (i.e., the constraint tree reflecting the ITS topology) would not be rejected in that case. Investigating the combined chloroplast + ITS data set led to rejection of the hypotheses representing the chloroplast topology and the ITS topology (in both cases, SOWH $p < 0.05$; PP=0; Table 2.12).

Support values throughout the ITS phylogeny are almost universally weak. For example, no analysis of the ITS data set yields any significant values supporting the monophyly of the *Nama hispida* clade or the *Nama dichotoma* clade, although both groups are recovered in the best-scoring ML trees and in the Bayesian consensus tree. Likewise, the monophyly of the *Nama stenophylla* clade has just 62% bootstrap support, although the posterior probability of the branch leading to that group is 1.00. The only deep-level relationship that receives bootstrap support is monophyly of the whole genus (BP = 100%; PP =1.00). Despite the lack of statistical support for many branches in the ITS phylogeny, hypotheses representing the best topologies of the chloroplast and the combined data sets were rejected by the SOWH test (Table 2.11). None of the post-stationarity trees from the Bayes analysis of ITS were consistent with the branching order of the seven major clades found in the chloroplast or combined topologies. In contrast, the AU test did not reject those topologies given the ITS dataset.

Incongruence between the chloroplast and ITS trees (and the largely intermediate combined chloroplast + ITS tree) is present at three levels. Most shallowly, species relationships within each of the seven major clades of *Nama* are frequently incongruent between the chloroplast and ITS topologies. However, there is little to no statistical support for relationships within each major clade of the ITS tree (Figures 2.8, 2.10 – 2.15, 2.14 – 2.15). Therefore it is not possible to say, given the available data, whether the incongruence truly reflects different evolutionary histories within each clade or is an artifact of the noisy ITS data. Outside of the seven major clades, the position of *N. stenocarpa* is incongruent with respect to its closest major clade allies. At the largest scale, the placement of the *Nama dichotoma* lineage is incongruent between the chloroplast and ITS topologies (Figure 2.6).

The *Nama dichotoma* clade is strongly supported to be sister to the *Nama hirsuta* clade in analyses of the chloroplast and combined chloroplast and ITS data sets (Figure 2.6). In contrast, all analyses of the ITS data set recover a grade with the *Nama hirsuta* clade at the base, followed by the *Nama dichotoma* clade, followed in turn by a metaclade comprising the *Nama jamaicensis* lineage, *N. stenocarpa,* the *Nama serpylloides* lineage, and the *Nama hispida* lineage. Despite the lack of bootstrap support for the ITS topology with respect to the *Nama dichotoma* and *Nama hirsuta* clades, hypothesis testing by means of both the SOWH test and Bayesian methods rejects a sister relationship of these two clades for the ITS data set ($p<0.05$; Table 2.11), although the hypothesis was not rejected by the AU test ($p=0.601$). No morphological synapomorphies have been found that definitively unite the *Nama dichotoma* clade with either the *Nama hirsuta* clade or the metaclade. However, the species of the *Nama hirsuta* clade variously share characteristics with a pair of species from the *Nama dichotoma* clade, *N. sericea* and *N. origanifolia*. *Nama quiexobrana* and *N. sericea* both have, for *Nama*, enormous corollas approaching 30 mm in length and inflorescences that are loose or lax cymes. *Nama hirsuta* likewise has lax cymes, but the corollas are much smaller (<15mm in length). *Nama sericea*, *N. origanifolia*, *N. hirsuta*, and *N. prostrata* all have prostrate or trailing habits. Finally, *N. quiexobrana*, *N. sericea*, and *N. origanifolia* are all characterized by unusually brittle stems (Bacon and McDonald 1991). Ecological evidence further supports a hypothetical close relationship between the *Nama hirsuta* and *Nama dichotoma* clades. Members of the *Nama dichotoma* clade are generally found in mesic, forested areas, as are all of the species of the *Nama hirsuta* clade. In contrast, the species of the metaclade are mostly restricted to deserts or arid regions, although this species-rich group contains at least three exceptions that grow in marshes or along streambanks. The two likeliest explanations for the observed incongruence in the position of the *Nama dichotoma* clade between the chloroplast and combined data sets and the ITS data set are a) that the phylogenies reconstructed from the chloroplast and nuclear genomes correctly reflect different evolutionary histories, and the *Nama dichotoma* clade is perhaps the result of an ancient hybridization event, or b) that association of the *Nama dichotoma* clade with the larger clade as seen in the phylogeny recovered from the ITS data set is an artifact that does not accurately reflect the evolutionary history of the group.

All analyses place *Nama stenocarpa* within the metaclade, although its closest relative within this large group varies by data set. The chloroplast and combined chloroplast and ITS data sets reconstruct a close relationship between *N. stenocarpa*, the *Nama serpylloides* clade, and the *Nama hispida* clade. All analyses of these data sets moderately to strongly support a monophyletic group composed of these three entities (BP >70, PP>0.95) but relationships among them are uncertain, with the chloroplast topology placing *N. stenocarpa* sister to the *Nama serpylloides* clade and the combined analyses placing *N. stenocarpa* sister to the *Nama serpylloides* clade plus the *Nama hispida* clade. In these analyses, the *Nama jamaicensis* clade is sister to this larger group. In contrast, all analyses of the ITS data set place *N. stenocarpa* sister to the *Nama jamaicensis* clade, although only the Bayesian analysis recovers any statistical support for this relationship (PP=0.91). Hypothesis testing conducted on the ITS data set rejected the chloroplast and combined topologies (i.e., a polytomy comprising *N. stenocarpa*, the *Nama serpylloides* clade, and the *Nama hispida* clade; Bayesian $PP<0.05$; SOWH test $p<0.05$)

Clues about the true phylogenetic position of *Nama stenocarpa* may come from morphological observations of the species in question and its potential relatives. *Nama stenocarpa* is, morphologically, quite different from other species of *Nama*. Both Jepson (1925) and Hitchcock (1933) considered it curious enough to merit segregation (Jepson erected the monotypic subgenus *Zonolacus*, which Hitchcock recombined to section *Zonolacus*). *Nama stenocarpa* is distinguished from all the other species in the genus by the possession of both a partially inferior ovary and styles that are completely united. Four other species have partially united styles: *N. densa*, *N. parviflora*, and *N. aretioides*, which are members of the *Nama densa* clade, have styles that are united up to ¾ of their length, and *N. jamaicensis* (of the eponymous clade) posesses styles which are often free but occasionally united up to ½ of the length. No species has the semi-inferior ovary of *N. stenocarpa*. However, in fruit, the calyces of *N. jamaicensis* harden and adhere to the capsule, giving the superficial appearance of an inferior ovary. The habitat for *N. stenocarpa* - wetland and riparian zones - is also uncommon within the genus. Like *Nama stenocarpa*, *N. jamaicensis* is also one of the rare riparian species of *Nama*; *N. biflora*, another species from the *Nama jamaicensis* clade, is also a wetland specialist. None of the species from the *Nama serpylloides* clade or the *Nama hispida* clade have been reported to prefer the mesic habitats that are typical of *N. stenocarpa*. Given these morphological and habitat clues, the association of *N. stenocarpa* with the *Nama jamaicensis* clade (as in the ITS phylogeny) rather than with the *Nama serpylloides* clade (as in the chloroplast and combined phylogenies) seems reasonable despite the low statistical support evident from the ITS data set.

The topological position of *Nama sandwicensis* is of particular interest because it is the sole hydrophyll that is endemic to the Hawaiian Islands, and it is unknown from which geographic region its ancestor originated; identification of its closest extant relative may assist in identifying this region. All analyses indicate that *N. sandwicensis* is a member of the *Nama hispida* clade. However, the phylogenies reconstructed from each data set are in disagreement regarding which taxon is most closely related to *N. sandwicensis*. The chloroplast data set yields a topology wherein *N. sandwicensis* falls in a grade at the base of the lineage between *N. berlandieri* and *N. hispida* var. *sonorae*, whereas the ITS data set places the clones of *N. sandwicensis* intermixed with the clones of two accessions of *N. berlandieri* (bs < 50% but PP=0.99; Figure 2.13). In general, the relationships among species in the *Nama hispida* clade are only weakly to moderately supported across all analyses; this is especially true for *N. retrorsa, N. turneri, N. coulteri, N. stevensii, N. hispida, N. xylopoda*, and *N. sandwicensis*. Given the very short branch lengths (Appendix A) in the *Nama hispida* clade, it is apparent that not enough differentiation has occurred among species to confidently identify the closest extant relative to *N. sandwicensis*.

Nama berlandieri and *N. undulata* var. *macrantha* have a twisted bit of nomenclatural history. Choisy (1833) erected *N. undulata* var. *macrantha* based on a specimen(s) from Moricand's herbarium "prope Mexico, Laredo, Matamoros." Hitchcock (1933b) believed that *N. berlandieri* was synonymous with *N. undulata* var.

macrantha and remarked that the variety was not "well marked," declaring that the type of *N. berlandieri* was identical to the plate in Choisy's description of *N. undulata* var. *macrantha*. It is possible but not clear that the illustration for var. *macrantha* was made from the collection that became the type of *N. berlandieri*; the type for *N. berlandieri* was collected near Reynosa, Mexico, and Choisy cited a collection from "Mexico, Laredo, Matamoros;" Reynosa is located along the U.S.-Mexico border about 1/3 of the distance from Matamoros to Laredo. Gray (1870) raised *N. undulata* var. *macrantha* to species status and called the entity *N. berlandieri*, citing Berlandier's collections *2116* and *699* from Reynosa, Mexico, expressing them as Berlandier 2116=699, indicating that he considered them duplicates of a single collection. The herbarium sheet at GH has both of those collections mounted on a single sheet. In 1913, Brand asserted that *N.berlandieri* was a hybrid of *N. jamaicensis* x *N. undulata*, citing Berlandier 2116; he also erected a new species, *N. macrantha*, of which he considered *N. undulata* var. *macrantha* to be a synonym. Brand designated Berlandier 699 as the type for *N. macrantha*. Finally, Hitchcock (1933b) reduced all of the above names published after 1833 to synonymy under *N. undulata* var. *macrantha*. In summary, Gray and Brand considered the taxon in question to merit specific status separate from *N. undulata*, while Hitchcock thought that the plants they saw were just a variety of the species, and not a very well-marked variety at that. Turner (pers. comm.) provided a persuasive argument for the possibility that the taxon is a distinct species based on style length and geographic distribution; I sampled *N. undulata* from Mexico (Chihuahua) and from Argentina (Catamarca, La Rioja, and San Juan) as well as samples tentatively identified as *N. berlandieri* from the Mexican states of Tamaulipas and San Luis Potosi. Preliminary analyses (not shown) showed that the South American accessions formed a monophyletic group with the *N. undulata* from Chihuahua, while the *N. berlandieri* samples formed a separate clade. For the final analyses I included one accession of *N. undulata* from Mexico and one from Argentina, as well as the two *N. berlandieri* accessions. All of the final analyses confirmed that the *N. berlandieri* specimens form a clade that was distinct from the *N. undulata* specimens. Given that interspecies relationships within the *Nama hispida* clade (of which *N. undulata* and *N. berlandieri* are members) are hazy, this consistent result seems significant and I therefore conclude that the two entities merit recognition as distinct species despite the apparent morphological similarity.

Early infrageneric classifications and correspondence of morphological characters to the molecular phylogeny

Of the 53 species included in this study, seven – *N. densa*, *N. parviflora* (previously a variety of *N. densa*) *N. aretioides*, *N. stenocarpa*, *N. spathulata*, *N. biflora*, and *N. jamaicensis* – have styles that are united to some degree. The first four species are characterized by styles that are fused all the way to the stigma, whereas the latter three species have styles that are fused only about halfway (Figure 2.20). All analyses show that *N. aretioides*, *N. densa*, and *N. parviflora* form a monophyletic group within the *Nama densa* clade (bs = 100%, PP=1.00). As discussed above, the position of *N. stenocarpa* is incongruent between the chloroplast and ITS phylogenies, however, it is clear that it is not sister to any of the other species with united styles. The remaining three species are all members of the *Nama jamaicensis* clade. The ITS phylogeny reconstructs a sister relationship between *N. jamaicensis* and *N. biflora* (bs<50% but PP=0.97; Figure 2.11); aside from that result, analyses indicate that none of the three species are sister to each other. Based on the molecular phylogenies, we can conclude that fused styles have certainly evolved more than once within *Nama*. The trait evolved once for the trio of *N. densa*, *N. aretioides*, and *N. parviflora*; once for *N. stenocarpa*; and either twice (given the ITS data set) or three times (given the chloroplast and combined data sets) for *N. jamaicensis*, *N. biflora*, and *N. spathulata,* for a total of four or 5 evolutionary gains. Alternatively, it is possible that in the last instance, there was a single gain of fused styles in the *Nama jamaicensis* clade followed by a series of losses. By this history, there would be three gains and five losses of fused styles (given the chloroplast data), three gains and one loss (given the combined data set), or two gains and three losses (given the ITS dataset, which reconstructs a sister relationship between *N. stenocarpa* and the *Nama jamaicensis* clade, so the single gain of fused styles would occur along the branch representing the most recent common ancestor of the two lineages).

Brand (1913) further organized *Nama* on the basis of stamen attachment to the corolla. Within subgenus *Marilaunidium* (i.e., all species without connate styles), he erected sections *Paleonama* and *Neonama*. *Paleonama* included all species in which the adnate portion of the filaments was less than one-third the total filament length; *Neonama* included all species in which the adnate portion represented more than half of the total filament length. Mapping this character onto the chloroplast tree (Figure 2.21) reveals that five of the seven major clades each have a single state for this character: the *Nama densa* and *Nama stenophylla* clades as well as *N. stenocarpa* all have filaments in which the free portion is much shorter than the adnate portion (i.e., corresponding to Brand's section *Neonama*). Species within the *Nama jamaicensis*, *Nama serpylloides*, and *Nama hispida* clades have filaments in which the free portion is much longer than the adnate portion (i.e., corresponding to Brand's section *Paleonama*). The *Nama dichotoma* clade and the *Nama hirsuta* clade both contain a mix of states for this character, with six species exhibiting long free filament portions and two species having very short free filament portions. The most parsimonious scenario, under all three alternate topologies (Figures 2.5 and 2.21), is that having the free portion of the filaments shorter than the adnate portion (i.e., Brand's section *Neonama*) is the ancestral state for the genus. All analyses clearly show that there are multiple state changes in this character and thus dividing the species of *Nama* into two groups based on the proportion of the filament length that is adnate to the corolla is not natural. The chloroplast and combined chloroplast and ITS topologies require five (5) state changes to arrive at the extant observed pattern, with either one or two changes to the "paleonama" condition and three or four reversals to the "neonama" condition. The ITS topology requires four (4) state changes, with a single change from "neonama" to the "paleonama" condition followed by three reversals.

Finally, we examined the correspondence of the informal seed groups described by Chance and Bacon (1984) to the chloroplast phylogeny, which had the best resolution and bootstrap support values among the trees generated by each data set (Figure 2.19). The informal seed groups corresponded quite well to the major clades that were present in the results of all analyses, so the results of testing the "seed group hypotheses" would be expected to be very similar regardless of which data set we selected. Monophyly of seed group 1 was not tested because its two members, *Nama lobbii* (subsequently reassigned to *Eriodictyon*) and *N. rothrockii*, are not included in the *Nama* ingroup. Subsequently, the monophyly of each seed group was tested individually by constraining the chloroplast data set to each seed group (Figure 2.5B-F). Monophyly of each of the individual seed groups was rejected because of one of two reasons; either the seed group in question as circumscribed by Chance and Bacon (1984) included members of one "major clade" plus a single unrelated species from elsewhere in the tree (this was the reason for rejection of seed groups 2, 3 and 4), or the seed group in question combined two unrelated "major clades" (this caused rejection of the monophyly of seed groups 5 and 6).

The hypothesis describing the monophyly of seed group 2 (Figure 2.5B), which includes the species of the *Nama hispida* clade plus *N. spathulata*, was not rejected by the AU test (p=0.998) but was rejected by the SOWH test and Bayesian posterior probability (SOWH p<0.05; PP=0.00). Pruning *N. spathulata* from the hypothesis led to an inability to reject the monophyly of the seed group by Bayesian methods (PP=1, indicating that all post-stationarity trees exhibited this clade) although it was still rejected by the SOWH test by a small margin (Table 2.10). It is possible that the inclusion of *N. spathulata* in seed group 2 – or in the *Nama jamaicensis* clade, where it is placed in the results of all analyses – is due to human error. First, there is potential nomenclatural confusion; in addition to the species called *N. spathulata*, there is a variety named *N. hispida* var. *spatulatum*. The taxa have unique type specimens and have not, to my knowledge, ever been considered to be synonymous with each other. However, given the similarity in names and the frequency with which varieties are raised to specific status and vice versa while maintaining the same epithet, it would be understandable if Chance and Bacon (1984) examined seeds of the *N. hispida* variety rather than the species *N. spathulata*. Likewise, it is possible that the specimen that we sampled was either misidentified or the contaminated at some time between DNA isolation and marker sequencing. I am confident that the specimen in question was correctly determined to be *N. spathulata*, and morphological evidence – such as the presence of semi-fused styles discussed above – suggests that the species is correctly placed in the *Nama jamaicensis* clade rather than the *Nama hispida* clade as are the other members of seed group 2.

Seed group 3 closely corresponds to the *Nama jamaicensis* clade and also includes *N. stenocarpa* (Figure 2.5C). The ITS data set reconstructs a sister relationship between these two entities, but I evaluated the seed groups against the chloroplast topology rather than the ITS phylogeny; the chloroplast data set instead recovers a close relationship between *N. stenocarpa* and the *Nama serpylloides* clade. Thus, using the chloroplast data set, I expected the monophyly of seed group 3 to be rejected because the hypothesis constrained of *N. stenocarpa* to be related to the *N. jamaicensis* lineage, and that is indeed what occurred (AU p-value = 0.002; SOWH p-value < 0.05; PP=0.00; Table 2.10). However, pruning *N. stenocarpa* from the hypothesis did not prevent rejection by any of the statistical tests (Table 2.10).

Seed group 4 encompasses the species of the *Nama stenophylla* clade plus *N. prostrata* (Figure 2.5D), which is placed by all molecular analyses in the *Nama hirsuta* clade (which Chance and Bacon {1984} referred to seed group 5). This inclusion in the constraint of a putatively unrelated species in the group led to rejection of the hypothesis describing a monophyletic seed group 4 (AU p-value = 2e -75; SOWH p-value <0.05; PP=0.00; Table 2.10). Chance and Bacon (1984) note that the seeds of *N. prostrata* are anomalous and have characteristics that may indicate that they are archetypical of seed groups 3, 4, and 5. What are the possible explanations for the incongruent placement of *N. prostrata* between the molecular phylogeny and seed group placement? It is possible that the error has been introduced into the molecular phylogeny, either through misidentification of the sample or through contamination. This explanation is invalidated by the fact that geographically, morphologically, and ecologically, *N. prostrata* is more similar to the other species of the *Nama hirsuta* clade than to the members of the *Nama stenophylla* clade . The species of the *Nama hirsuta* clade are weak-stemmed perennials (*N. prostrata* is variously reported as an annual and a perennial) of mesic west-central highlands in Mexico with membranous, broad, heart-shaped leaves; the species of the *Nama stenophylla* clade are generally woody perennials from gypsum deposits in the Chihuahuan Desert and adjacent arid regions of Nuevo Leon; most have linear, succulent leaves. The phylogenies based on molecular data reflect the morphological and ecological observations and reject a close relationship between *N. prostrata* and the *Nama stenophylla* clade. The other explanation for the disagreement between the seed group assignment and the molecular phylogeny is that *N. prostrata* may have been incorrectly assigned to seed group 4. Indeed, Chance and Bacon (1984) describe thickenings that are not limited to the reticulum cell walls but traverse the floor of the reticulum cells, which is the hallmark of seed group 5. Furthermore, in their description of *N. quiexobrana* (a member of the *Nama hirsuta* clade), Bacon and McDonald (1991) assigned that species to seed group 5 and specified that its seeds are most similar to *N. prostrata* and *N. hirsuta*, presumably uniting all three species in a single seed group. I conclude, then, that based on the seed group descriptions as composed by Chance and Bacon and the SEMs published in their research, that assignment of *N. prostrata* to seed group 5 is a reasonable proposition. Interestingly, removal of *N. prostrata* from the hypothesis did not prevent rejection by the AU test ($p < 0.01$; Table 2.10), which is the least rigorous of the three tests we performed. The modified hypothesis was unable to be rejected by Bayesian PP (PP=1.00), and was rejected by the SOWH test ($p<0.05$) by a very slim margin. Rejection of the hypothesis by the SOWH test is attributable to the very flat distribution of δ for the simulated data sets: the range of δ for the simulated data sets was from -0.0011 to 0.0022, while the observed $\delta = 0.00079$. While this is an extremely small difference between the ML score of the best chloroplast tree and the best tree having the constraint (a monophyletic seed group 4, excluding *N. prostrata*), it is still outside the 95% confidence interval of score differences.

The species assigned to seed group 5 comprise the *Nama serpylloides* clade and the *Nama hirsuta* clade (excluding *N. prostrata*, which was assigned to seed group 4). No analyses of any of the data sets indicate that these two clades are related, so it is not surprising that all statistical tests that we performed rejected the monophyly of this seed group (AU p-value <0.01; SOWH p-value < 0.05; PP=0.00; Table 2.10). Chance and Bacon (1984) expressed ambivalence regarding the unity of seed group 6, and indeed, molecular analyses confirm that the members of this seed group are separated into two disparate clades, the *Nama densa* clade and the *Nama dichotoma* clade. No analysis of molecular data recovered any close relationship of these two clades, so it is unsurprising that, as for seed group 5, all statistical tests rejected the monophyly of seed group 6 (AU p-value <0.01; SOWH p-value < 0.05; PP=0.00; Table 2.10).

CONCLUSIONS

Analyses of the chloroplast data set yield a strongly supported phylogeny of *Nama* comprising seven major lineages. Analyses of the ITS data set recover the same seven clades, however, there is generally less support throughout the ITS tree. The positions of *N. stenocarpa* and the *Nama dichotoma* lineage are incongruent between, but otherwise, the two trees are in agreement regarding the relationships among the major lineages. Among morphological characters that have historically been used for infrageneric classification, fully united styles and features of the seed surface generally correlate to groups united by common ancestry. Future work should target the identification of a low-copy nuclear marker to be sequenced across *Nama* to enhance our understanding of interspecies relationships in the genus. In particular, our understanding of relationships among the species of the *Nama hispida* lineage would be greatly enhanced by additional genetic sampling as well as concentrated morphological investigation of this challenging group.

Table 2.1. List of accepted species and varieties within *Nama*.

Core *Nama* (52 species, 18 varieties)	
N. aretioides (Hook. and Arn.) Brand	*N. marshii* (Standl.) I.M. Johnst.
var. *multiflorum* (A. Heller) Jeps.	*N. origanifolia* H.B.K.
N. berlandieri A. Gray	var. *rupicola* (Bonpl. ex Choisy) C.L. Hitchc.
N. bartlettii Standl.	*N. orizabensis* D.L. Nash
N. biflora Choisy	*N. palmeri* A. Gray ex Hemsl.
N. californica (A. Gray) J.D. Bacon	*N. parviflora* (Greenm.) Constance
N. canescens C.L. Hitchc.	*N. parvifolia* (Torr.) Greenm.
N. carnosa (Wooton) C.L. Hitchc.	*N. pringlei* B.L. Rob. and Greenm.
N. constancei J.D. Bacon	*N. propinqua* C.V. Morton and C.L. Hitchc.
N. coulteri A. Gray	*N. prostrata* Brand
*N. cuatrocienegensis*G.L. Nesom	*N. pueblensis* B.L. Rob. and Greenm.
N. demissa A. Gray	*N. pusilla* Lemmon ex A. Gray
var. *covillei* Brand	*N. quiexobrana* J.D. Bacon and J.A. McDonald
var. *deserti* Brand	*N. retrorsa* J.T. Howell
var. *linearis* C.L. Hitchc.	*N. rotundifolia* (A. Gray) J.F. Macbr.
N. densa Lemmon	*N. rzedowskii* J.D. Bacon
N. depressa Lemmon ex A. Gray	*N. sandwicensis* A. Gray
N. dichotoma (Ruiz and Pav.) Choisy	*N. schaffner*i A. Gray ex Hemsl.
var. *amplifolia* (Brand) C.L. Hitchc.	*N. segetalis* Ricketson
var. *chasmogama*Brand	*N. sericea* Willd. ex Roem. & Schult.
var. *latisepala* (Loes.) C.L. Hitchc.	*N. serpylloides* A. Gray ex Hemsl.
N. ehrenbergii Brand	var. *conferta* I.M. Johnst.
N. flavescens Brandegee	var. *velutina* C.L. Hitchc.
N. havardii A. Gray	*N. spathulata* Brandegee
var. *album* Cory	*N. stenocarpa* A. Gray
N. hintoniora G.L. Nesom	*N. stenophylla* A. Gray ex Hemsl.
*N. hirsuta*M. Martens and Galeotti	*N. stevensii* C.L. Hitchc.
N. hispida A. Gray	var. *gypsicola* (I.M. Johnst.) J.D. Bacon
var. *mentzelii* Brand	*N. torynophylla* Greenm.
var. *revoluta* Jeps.	*N. turneri* J.D. Bacon
var. *sonorae* C.L. Hitchc.	*N. undulata* H.B.K.
var. *spathulata*(Torr.) C.L. Hitchc.	var. *australis* C.L. Hitchc.
N. hitchcockii J.D. Bacon	var. *macrantha* Choisy
N. jamaicensis L.	*N. xylopoda*Wooton and Standl.
N. johnstonii C.L. Hitchc.	
N. linearis I.M. Johnst.	
Undescribed Species (4; in prep)	
N. "baconii"	*N. "monclova"*
N. "jimulco"	*N. "whalenii"*

Table 2.2. Summary of subgeneric classifications of *Nama*, 1913 – 1933. Numbers in parentheses indicate the number of species in each subgeneric taxon. Asterisks (*) indicate subgenera or sections comprising species that have been excluded from *Nama*.

Author	Subgenus	Section	Total # of species
A. Brand (1913)	***Conanthus*** (7): Styles fused for some portion ***Marilaunidium*** (30): Styles free to base	***Paleonama*** (20): Free portion of anther filaments longer than the adnate portion ***Neonama*** (10): Free portion of anther filaments shorter than adnate portion	37
W.L. Jepson (1925)	***Conanthus*** (2): Styles fused for some portion ***Zonolacus*** (1): Styles connate, ovary half-inferior ***Neonama*** (4): Annuals, leaves entire, styles distinct ***Lobbiana*** (1)*:Perennials, stems procumbent ***Rothrockia*** (1)*:Perennials, stems short and herbaceous, leaves toothed or pinnatifid ***Turricula*** (1)*: Perennials, stems tall and woody, leaves revolute		10 (CA only)
C.L. Hitchcock (1933)		***Conanthus*** (2): Styles fused for some portion ***Zonolacus*** (1): Calyx united up to 1/4 length, tubular portion adnate to ovary ***Eunama*** (=*Nama*; 27): Styles free, leaves entire, capsule membranous ***Arachnoidea*** (1)*: Styles free, leaves entire, capsule cartilaginous ***Cinerascentia*** (1)*: Styles free, leaves crenate-dentate	32

Table 2.3. Informal “Seed Groups” described by Chance and Bacon (1984). “Number of Species” column includes species examined by Chance and Bacon as well as species assigned at a later date by Bacon (1987) and Nesom (1991, 1992b).

Seed Group	Description	Number of Species
1	Seed coat solid, 45-60 um thick, pitted surface	2
2	Seed coat solid, 2-5 um thick, surface foveolate and ridged	5
3	Seed coat chambered, surface reticulate with pits in the radial walls of the reticula and knobs on the reticulum rims	7
4	Seed coat chambered, surface reticulate with thickenings in the radial walls of the reticula	9
5	Seed coat chambered, surface reticulate with "U"-shaped thickenings in each reticulum	7
6	Seed coat chambered, surface having undulate chamber walls	10

Table 2.4. Voucher specimens sampled for molecular phylogenetic analyses.

Taxon	**Acc. Number**	**Collector**	**Collector Number**	**Country**	**State**	**Collection Date**	**Herb**
Nama aretioides	112	J.D. Morefield, D.H. McCarty	3583	USA	California	5-May-86	TEX
Nama baconii	159	B.L. Turner	15418	Mexico	Veracruz	29-Oct-83	TEX
Nama bartlettii	110	G. Nesom et al.	6052	Mexico	Tamaulipas	17-Jun-87	TEX
Nama berlandieri	114	W.R. Carr w/C. Best	13423	USA	TX	29-Mar-94	TEX
Nama berlandieri	214	S.J. Taylor	153	Mexico	San Luis Potosi	13-Oct-07	TEX
Nama biflora	109	T.F. Patterson et al.	7399	Mexico	Nuevo Leon	16-Oct-93	TEX
Nama biflora	131	Hinton et al.	24420	Mexico	Nuevo Leon	16-Jun-94	TEX
Nama biflora	132	L.E. Brown	13388	Mexico	Tamaulipas	21-Dec-88	TEX
Nama californica	202	C.F. Smith	2000	USA	California	3-May-47	TEX
Nama californica	217	C.F. Smith	2000	USA	California	3-May-47	TEX
Nama canescens	102	Hinton et al.	22346	Mexico	Nuevo Leon	26-Aug-92	TEX
Nama canescens	155	S.E. Jackson	109	Mexico	Nuevo Leon	18-Aug-03	TEX
Nama canescens	212	S.J. Taylor	151	Mexico	Nuevo Leon	13-Oct-07	TEX
Nama canescens	219	S.J. Taylor	151	Mexico	Nuevo Leon	13-Oct-07	TEX
Nama canescens	220	S.J. Taylor	147	Mexico	Nuevo Leon	12-Oct-07	TEX
Nama carnosa	101	B.L. Turner	20-450	USA	Texas	1-Aug-00	TEX
Nama constancei	103	J. Henrickson	205303	Mexico	Coahuila	25-Sep-98	TEX

Table 2.4 (continued)

Nama constancei	149	S.E. Jackson	102	Mexico	Coahuila	15-Aug-03	TEX
Nama coulteri	130	A.T. Whittemore w/F. Barrie, J. Bacon	83-098	Mexico	Sonora	19-Mar-83	TEX
Nama cuatrocienegensis	161	Venable & McCormick	769	Mexico	Coahuila	22-Mar-75	TEX
Nama demissa	196	S.J. Taylor	129	USA	California	18-Mar-05	TEX
Nama demissa	197	S.J. Taylor	125	USA	California	16-Mar-05	TEX
Nama demissa	199	S.J. Taylor	124	USA	California	15-Mar-05	TEX
Nama demissa	111	D. Charlton	1291	Mexico	California	6-Mar-88	TEX
Nama densa	207	L. Constance w/E. Molseed, R. Ornduff	3716	USA	Nevada	19-Jul-61	TEX
Nama densa	129	N.H. Holmbren, J.R. Reveal	1914	USA	Utah	12-Jun-65	TEX
Nama depressa	200	L. Constance	3403	USA	California	9-Apr-52	TEX
Nama dichotoma	104	R.D. Worthington	3501	USA	Texas	16-Sep-78	TEX
Nama dichotoma var. chasmogama	225	D.E. Breedlove, F. Almeda	59391	Mexico	Hidalgo	27-Oct-83	TEX
Nama dichotoma var. dichotoma	226	B.L. Turner	15276	Mexico	Puebla	24-Sep-83	TEX
Nama dichotoma var. latisepala	224	I. Diaz V. w/A. Valverde G.	169	Mexico	Hidalgo	25-Aug-88	TEX
Nama flavescens	135	M.C. Johnston, T.L. Wendt, F. Chiang	11543A	Mexico	Zacatecas	1-Jul-73	TEX
Nama havardii	106	M. Turner (w/J. Robbins)	83	USA	Texas	20-Mar-99	TEX
Nama hintoniora	137	G.B. Hinton	25838	Mexico	Nuevo Leon	14-Sep-96	TEX

Table 2.4 (continued)

Nama hintoniora	230	C.P. Cowan w/M.A. Carranza P.	3571	Mexico	Coahuila	18-Aug-82	TEX
Nama hintoniora	231	T.F. Patterson	5948	Mexico	Nuevo Leon	4-Jul-88	TEX
Nama hirsuta	136	F.R. Barrie w/J.D. Bacon, L. Geischen	410	Mexico	Oaxaca	31-Aug-82	TEX
Nama hirsuta	192	L.O. Williams, A. Molina R., T.P. Williams	25877	Guate-mala	San Marcos	13-Dec-63	NY
Nama hispida	143	S.E. Jackson	III-03-3	USA	Texas	30-Mar-03	TEX
Nama hispida	107	B.L. Turner	21-30	USA	Texas	2-Mar-01	TEX
Nama hispida	141	S.E. Jackson	III-03-2	USA	Texas	30-Mar-03	TEX
Nama hispida	142	S.E. Jackson	III-03-1	USA	Texas	30-Mar-03	TEX
Nama hispida	145	S.E. Jackson	V-03-1	USA	Texas	3-May-03	TEX
Nama hispida	146	S.E. Jackson	V-03-4	USA	Texas	3-May-03	TEX
Nama hispida	147	S.E. Jackson	V-03-5	USA	Texas	3-May-03	TEX
Nama hispida var. sonorae	133	A.T. Whittemore w/F. Barrie, J. Bacon	83-052	Mexico	Sonora	Mar-83	TEX
Nama hispida var. spatulata	195	S.J. Taylor	119	USA	California	14-Mar-05	TEX
Nama hitchockii	134	G. Nesom w/M. Mayfield, G.S. Hinton	7615	Mexico	Nuevo Leon	18-Sep-93	TEX
Nama hitchockii	210	S.J. Taylor	149	Mexico	Nuevo Leon	12-Oct-07	TEX
Nama hitchockii	223	S.J. Taylor	149	Mexico	Nuevo Leon	12-Oct-07	TEX
Nama jamaicensis	115	W.R. Carr	16048	USA	Texas	8-Apr-97	TEX

Table 2.4 (continued)

Nama "jimulco"	138	J.A. Villarreal w/M.A. Carranza	4420	Mexico	Coahuila	25-Aug-98	TEX
Nama johnstonii	139	Hinton et al.	23340	Mexico	Coahuila	19-Sep-93	TEX
Nama lobbii	158	Barclay, Barbee, & Bloom	s.n.	USA	California	7-Jul-62	TEX
Nama marshii	208	I.M. Johnston	9230	Mexico	Coahuila	18-Sep-41	TEX
Nama "monclova"	163	Prather w/Patterson & Hempel	1482B	Mexico	Nuevo Leon	18-Oct-93	TEX
Nama origanifolia	125	A.T. Whittemore w/F. Barrie, J. Bacon	83-004	Mexico	Durango	16-Mar-83	TEX
Nama palmeri	123	J. Panero, I. Calzada	6875	Mexico	Nuevo Leon	11-Nov-96	TEX
Nama palmeri	124	Hinton et al.	25361	Mexico	Nuevo Leon	22-Jul-95	TEX
Nama palmeri	213	S.J. Taylor	152	Mexico	San Luis Potosi	13-Oct-07	TEX
Nama palmeri	221	S.J. Taylor	152	Mexico	San Luis Potosi	13-Oct-07	TEX
Nama parviflora	206	J.L. Gentry, Jr. w/G. Davidse	1518	USA	Nevada	14-Jun-67	TEX
Nama parvifolia	113	B. Ertter w/J. Larke	5255	USA	Texas	11-Dec-83	TEX
Nama parvifolia	144	S.E. Jackson	III-03-4	USA	Texas	30-Mar-03	TEX
Nama pringlei	122	C.P. Cowan w/M. Luckow, D. Kearns, N. Jacobson	5770	Mexico	Puebla	Sep-85	TEX
Nama propinqua	121	M.C. Johnston, T.L. Wendt, F. Chiang	7550A	Mexico	Coahuila	7-Jun-72	TEX

Table 2.4 (continued)

Nama propinqua	162	Nesom w/Mayfield		Mexico	Coahuila	3-Jun-92	TEX
Nama prostrata	120	J. Garcia P.	932	Mexico		10-Feb-79	TEX
Nama pueblensis	119	A. Salinas T. w/A.R. Garcia	4914	Mexico	Puebla	23-Aug-88	TEX
Nama pusila	128	J.D. Morefield, D.H. McCarty	3594	USA	California	6-May-86	TEX
Nama pusila	196	S.J. Taylor	129	USA	California	18-Mar-05	TEX
Nama quiexobrana	118	Hinton et al.	26807	Mexico	Oaxaca	7-Aug-96	TEX
Nama retrorsa	193	L.C. Higgins, B. Welsh	13177	USA	Utah	23-May-83	NY
Nama rothrockii	108	S. Morgan, H. Soldan	s.n.	USA	California	27-May-90	TEX
Nama sandwicensis	201	W.H. Wagner, Jr.	5448	USA	Hawaii	2-Aug-47	TEX
Nama schaffneri	116	J. Valdes., M.A. Carranza	R.2306	Mexico	Nuevo Leon	4-Sep-93	TEX
Nama sericea	164	Hinton et al.	23492	Mexico	Nuevo Leon	22-Sep-93	TEX
Nama sericea	165	Panero w/Calzada & Kim	3712	Mexico	Queretaro	12-Oct-93	TEX
Nama serpylloides var. serpylloides	173	Hartman w/Sanderson	3541	Mexico	Coahuila	28-May-73	TEX
Nama serpylloides var. serpylloides	174	Giescher	s.n.	Mexico	Nuevo Leon	28-Aug-82	TEX
Nama serpylloides var. velutina	166	Powell & Turner	2258	Mexico	Coahuila	20-May-72	TEX
Nama spathulata	167	Tenorio w/Romero de T.	7457	Mexico	Teotepec	27-Sep-84	TEX

Table 2.4 (continued)

Nama stenocarpa	127	L. Hernandez w/Mahinda Martinez	2315	USA	Texas	7-Apr-89	TEX
Nama stenophylla	152	S.E. Jackson	106	Mexico	Coahuila	16-Aug-03	TEX
Nama stenophylla	153	S.E. Jackson	107	Mexico	Coahuila	16-Aug-03	TEX
Nama stenophylla	154	S.E. Jackson	108	Mexico	Coahuila	17-Aug-03	TEX
Nama stevensii	126	D.S. Correll w/David Flyr	38390	USA	Texas	8-Apr-70	TEX
Nama stevensii	156	S.E. Jackson	110	Mexico	San Luis Potosi	18-Aug-08	TEX
Nama havardii	203	I.M. Johnston, C.H. Muller	228	Mexico	Coahuila	13-Aug-40	TEX
Nama havardii	204	R.M. Stewart	598	Mexico	Coahuila	23-Jun-41	TEX
Nama havardii	205	A.M. Powell, B.L. Turner, R.E. Magill	1990	Mexico	Chihuahua	5-Apr-71	TEX
Nama torynophylla	105	B.L. Turner	21-5	USA	Texas	23-Feb-01	TEX
Nama turneri	168	R.L. McGregor	s.n.	Mexico	SLP	8-Apr-61	TEX
Nama undulata	169	Spencer w/Atwood	445	Mexico	Chihuahua	10-Jul-97	TEX
Nama undulata	185	S.J. Taylor	130	Argentina	San Juan	14-Jan-06	TEX
Nama undulata	186	S.J. Taylor	131	Argentina	La Rioja	16-Jan-06	TEX
Nama undulata	187	S.J. Taylor	132	Argentina	Catamarca	17-Jan-06	TEX
Nama "whalenii"	171	Wendt, Lott, & Mispagel	1838	Mexico	Coahuila	29-Sep-76	TEX
Nama "whalenii"	172	Chiang, Wendt, & M.C.Johnston	9555e	Mexico	Coahuila	27-Sep-72	TEX
Nama xylopoda	157	S. Sikes, J. Smith	533	USA	Texas	12-Jun-73	TEX

Table 2.4 (continued)

Ehretia anacua	175	L. Hernandez w/Mahinda Martinez	2333	USA	Texas	9-Apr-89	TEX
Emmenanthe penduliflora	181	T. Ross, S. Boyd, L. Arnseth	4808	USA	California	29-Apr-91	TEX
Eriodictyon californicum	183	D.S. Lujan	50	USA	California	13-May-72	TEX
Eriodictyon crassifolium var. nigrens	182	T.S. Ross, S. Boyd	8166	USA	California	7-Jul-94	TEX
Eriodictyon trichocalyx ssp. Lanatum	184	A.C. Sanders, M. Elvin, C. Burrascano, A. Pignoli, A. Thompson et al.	26517	USA	California	4-May-03	TEX
Phacelia congesta	180	B.L. Turner	21-221	USA	Texas	6-Apr-01	TEX
Phacelia rotundifolia	176	J.D. Morefield, D.H. McCarty	3274 (dupl. m)	USA	California	18-Mar-86	TEX
Tricardia watsonii	179	J.D. Morefield, D.H. McCarty	3375 (dupl. n)	USA	California	10-Apr-86	TEX
Turricula parryi	177	T.S. Ross, S. Boyd	7875	USA	California	24-May-94	TEX
Wigandia caracasana	178	C.P. Cowan	4914	Mexico	Michoacan	17-Dec-14	TEX

Table 2.5. Primer sequences used in this study.

Region	Primer ID	Primer Sequence	Citation
***mat*K**	1F	5'-ACT GTA TCG CAC TAT GTA TCA-3'	Sang et al. 1997
	8F	5’-CAA TTC ATT CA(A/C) TAT TTC CTT-3’	Johnson and Soltis 1995
	590F* *Nama*	5'-ARG AYG CCK CTT CTT TGC AT-3'	Sang et al. 1997, modified for this study
	1100F	5'-CTA AAC CCC TCA ATG GTA CG-3'	Designed for this study
	778R	5'-CAA GAA GGG CTC CAG AAG ATG-3'	Designed for this study
	1320R	5’-GAT CCG CTG TGA TAA TGA GA-3’	Sang et al. 1997, modified for *Tiquilia* by Moore (2005)
	1408R	5’-ATT TCC GAG CCR AAT CTT TT-3’	Designed for this study
	trnK2R	5'-AAC TAG TCG GAT GGA GTA G-3'	Sang et al. 1997; Johnson and Soltis 1995
***ndh*F**	1(F)	5'-AGG TAA GAT CCG GTG AAT CGG AAA C-3'	Mast et al. 2008
	3	5'-TAC TTC CAT GTT GGG ATT AGT TAC TAG-3'	Jansen 1992
	972Rep2	5'-TAT TCT AGG AGC TAC TTT AG-3'	Designed for this study, based on Olmstead and Sweere 1994
	7	5'-AGG TAC ACT TTC TCT TTG CGG TAT TCC-3'	Jansen 1992
	1704F	5’-TAT TTA CTT TGT TCG TTG -3’	Designed for this study
	722* *Nama*	5'-TAA YAG AMC GGC ACA TAA AGT AGC-3'	Designed for this study
	8	5'-ATA GAT CCG ACA CAT ATA AAA TGC GGT G-3’	Jansen 1992
	2110R	5'-CCC CCT AYA TAT TTG ATA CCT TCT CC-3'	Olmstead and Sweere 1994
ITS	p1a	5'-GGA AGG AGA AGT CGT AAC AAG G-3'	Kim and Jansen 1994
	p4	5'-TCC TCC GCT TAT TGA TAT GC-3'	Kim and Jansen 1994
	M13F	5'-GTAAAACGACGGCCAG-3'	TOPO TA
	M13R	5'-CAGGAAACAGCTATGAC-3'	TOPO TA

Table 2.6. Characteristics of the chloroplast and ITS data sets, including partitions within each data set.

Data Set	**Align-ed length (bp)**	**Total number of excluded characters (bp)**	**Model selected by Mr Modeltest**	**MrBayes lnL (arithmet-ic mean)**	**RAxML lnL (best)**	**GARLI lnL (best)**
Chloroplast (*mat*K + ndhF)	4021	0	GTR+I+G	-14499.15	-14079.762	-13769.465
Chloroplast (*trn*K introns)	314	17	GTR+G	n/a	n/a	n/a
Chloroplast (*mat*K coding)	1518	0	GTR+I+G	n/a	n/a	n/a
Chloroplast (*ndh*F noncoding)	46	0	HKY+I	n/a	n/a	n/a
Chloroplast (*ndh*F coding)	2143	0	GTR+I+G	n/a	n/a	n/a
ITS (entire)	764	0	GTR+G	-12095.10	-11647.873	-11753.669
ITS (18S)	54	0	K80	n/a	n/a	n/a
ITS (ITS1)	239	0	GTR+G	n/a	n/a	n/a
ITS (5.8S)	164	0	SYM	n/a	n/a	n/a
ITS (ITS2)	249	31	GTR+G	n/a	n/a	n/a
ITS (25S)	58	0	K80+G	n/a	n/a	n/a
Combined chloroplast+ITS	4785	48	n/a	-20611.62	n/a	-20722.931

Table 2.7. Summary of missing data for the ITS, *mat*K, and *ndh*F data sets. Accessions with less than 10% missing data are not listed. For the ITS data set, unlisted accessions had less than 5% missing data; for the *mat*K data set, unlisted accessions had less than 7% missing data; for the *ndh*F data set, unlisted accessions had less than 4% missing data.

Accession	**% Missing (ITS)**	**% missing (*mat*K)**	**% missing (*ndh*F)**
N. biflora 109.10	11.9		
N. biflora 109.4	11.6		
N. biflora 109.6	12.0		
N. biflora 109.8	15.2		
N. densa 207.8	17.1		
N. palmeri 123.4	37.3		
N. palmeri 123.5	18.3		
N. palmeri 123.7	15.9		
N. stenophylla 152.2	11.3		
N. stenophylla 152.3	11.8		
N. stenophylla 152.5	11.4		
N. torynophylla 105.10	11.9		
N. torynophylla 105.20	11.9		
N. torynophylla 105.4	11.8		
N. torynophylla 105.5	12.0		
N. stenophylla 152.1	10.9		
Turricula parryi 177.5	15.8		
N. californica 202		23.1	39.0
N. canescens 212		33.0	
N. depressa 200		32.2	68.0
N. dichotoma 226		28.3	
N. dichotoma 226		59.0	
N. dichotoma var. chasmogama-225		59.2	22.9
N. dichotoma var. latifolia 224		60.9	
N. hitchcockii 210		60.6	
N. marshii 208		60.5	66.3

Table 2.8. Voucher information, measurements, and seed group assignment for specimens examined with scanning electron microscopy.

Species	**Voucher**	**Seed Length (υm)**	**Seed Width (υm)**	**Testa Thickness (υm)**	**Seed Group**
N. californica	Smith 2000; 3 May 1947	850	525	9.2 -- 9.9	6
N. berlandieri	Walker s.n.; 9 Feb 1942	365	274	3 -- 5	2
N. biflora	Rzedowski 4779; 22 Sep 1954	550 -- 585	485 -- 495	n/a	3
N. coulteri	Whittemore 83-098; 19 Mar 1983	440 -- 455	250 -- 300	n/a	2
N. cuatrocienegensis	Venable & McCormick 769; 22 Mar 1975	279 -- 295	212 -- 222	n/a	5
N. pringlei	Cowan 5770; 23 Sep 1985	550 -- 610	400 -- 420	n/a	6
N. pueblensis	Salinas T. 4914; 23 Aug 1988	650 -- 660	375 -- 480	7.5 -- 16.5	6
N. pueblensis	Henrickson 6352; 2 Sep 1971	688 -- 718	360 -- 415	13 -- 20	6
N. quiexobrana	Hinton et al. 26219; 19 Oct 1995	925 -- 966	424 -- 700	ca. 40	5
N. spatulata	Valdes R. 2306; 4 Sep 1993	966	681	n/a	3
N. stewartii (=N. havardii)	Johnston & Muller 228; 13 Aug 1940	444 -- 517	342 -- 367	n/a	4
N. xylopoda	Correll & Johnston 24277; 7 Sep 1961	437 -- 513	271 -- 283	n/a	2

Table 2.9. Clades recovered in all analyses. The placement of *N. rzedowskii* in the *Nama serpylloides* lineage is tentative, based on opposite phyllotaxy.

clade name	**species**
Nama densa clade	*N. aretioides*
	N. californica
	N. demissa
	N. densa
	N. depressa
	N. parviflora
	N. pusilla
Nama dichotoma clade	*N. "baconii"*
	N. dichotoma
	N. origanifolia
	N. pringlei
	N. pueblense
	N. sericea
	N. "whaleni"
Nama serpylloides clade	*N. cuatrocienegensis*
	N. parvifolia
	*N. rzedowskii**
	N. serpylloides
	N. torynophylla
Nama stenophylla clade	*N. canescens*
	N. carnosa
	N. constancei
	N. flavescens
	N. havardii
	N. hitchcockii
	N. “jimulco”
	N. johnstonii
	N. stenophylla
Nama hirsuta clade	*N. hirsuta*
	N. prostrata
	N. quiexobrana
Nama jamaicensis clade	*N. bartlettii*
	N. biflora
	N. hintoniora
	N. jamaicensis
	N. marshii
	N. palmeri
	N. propinqua
	N. schaffneri
	N. spatulata
Nama hispida clade	*N. berlandieri*
	N. coulteri
	N. hispida
	N. "monclova"
	N. retrorsa
	N. sandwicensis
	N. stevensii
	N. turneri
	N. undulata
	N. xylopoda
"unassigned"	*N. stenocarpa*

Table 2.10. Hypothesis testing outcomes, chloroplast data set. Results indicating inability to reject hypotheses denoted with †.

Hypothesis/constraint	AU test p-value	SOWH test p-value	Bayesian posterior probability
Monophyly of all Chance and Bacon (1984) informal seed groups, tested simultaneously	n/a	<0.05	0.0000
Monophyly of Chance and Bacon (1984) Seed Group 2	**0.998†**	0.02<p<0.05	**1†**
Monophyly of Chance and Bacon (1984) Seed Group 3	0.002	<0.05	0.0000
Monophyly of Chance and Bacon (1984) Seed Group 3, excluding *Nama stenocarpa*	<0.01	<0.05	0.0000
Monophyly of Chance and Bacon (1984) Seed Group 4	<0.01	<0.05	0.0000
Monophyly of Chance and Bacon (1984) Seed Group 4, excluding *Nama prostratum*	<0.01	0.01<p<0.05	**1†**
Monophyly of Chance and Bacon (1984) Seed Group 5	<0.01	<0.05	0.0000
Monophyly of Chance and Bacon (1984) Seed Group 6	<0.01	<0.05	0.0000
Topology of the combined chloroplast + ITS ML tree	n/a	<0.05	0.0000

Table 2.11. Hypothesis testing outcomes, ITS data set. Results indicating inability to reject hypotheses denoted with †.

Hypothesis/constraint	AU test p-value	SOWH test p-value	Bayesian posterior probability
Topology of the combined-1 best tree	**0.283†**	<0.05	n/a
Topology of the chloroplast best tree	**0.535†**	<0.05	0.00
The *Nama dichotoma* clade sister to the *Nama hirsutum* clade	**0.601†**	<0.05	<0.01
The *Nama stenophylla* clade sister to the metaclade	**0.288†**	<0.05	<0.01
Polytomy consisting of *Nama stenocarpa*, the *Nama serpylloides* clade, and the *Nama hispida* clade	n/a	n/a	<0.01

Table 2.12. Hypothesis testing outcomes, combined chloroplast + ITS data set.

Hypothesis/constraint	**SOWH test p-value**	**Bayesian posterior probability**
Topology of ITS best tree (major lineages)	<0.05	0.00
Topology of chloroplast best tree (major lineages)	<0.05	0.00

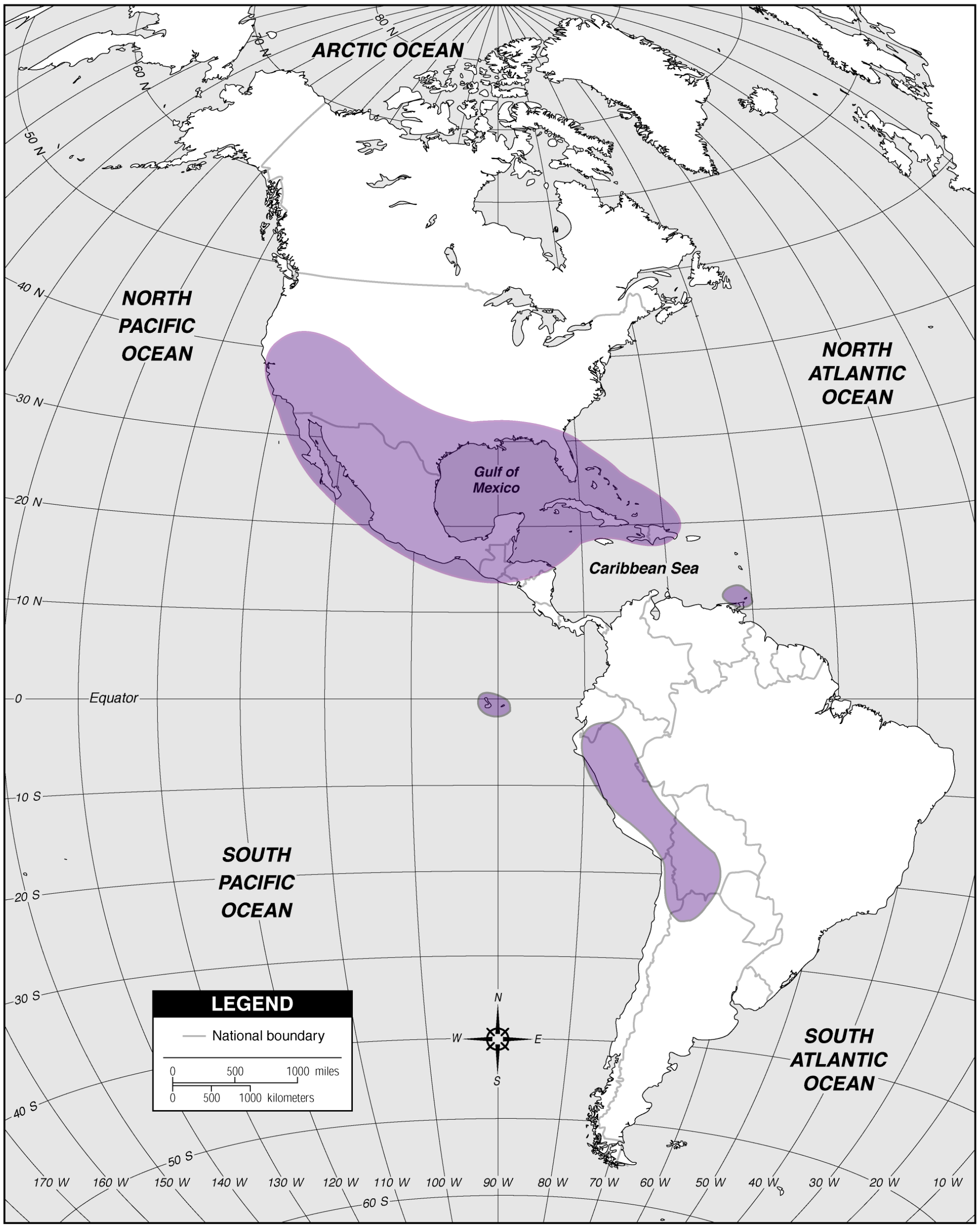


Figure 2.1: Global distribution map of *Nama* (Boraginaceae).

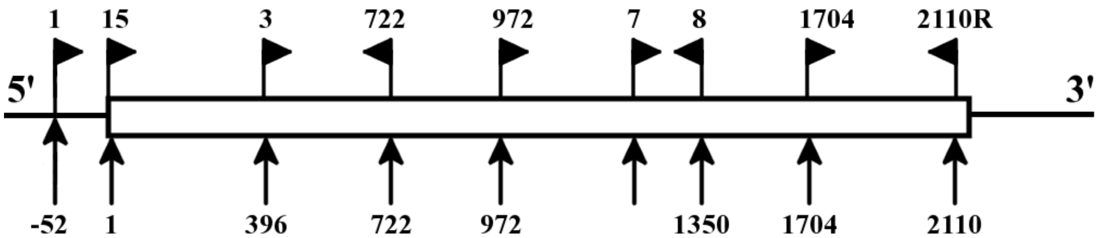


Figure 2.2: Schematic of *ndh*F region. Arrows and numbers below indicate base position of primers. Arrows and numbers above indicate primer name and direction. Primer sequences are available in Appendix A.

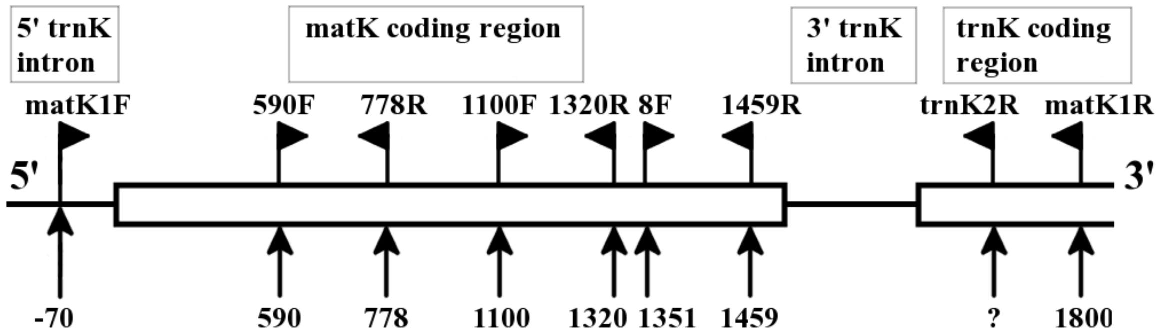


Figure 2.3: Schematic of *mat*K region. Arrows and numbers below indicate base position of primers. Arrows and numbers above indicate primer name and direction. Primer sequences are available in Appendix A.

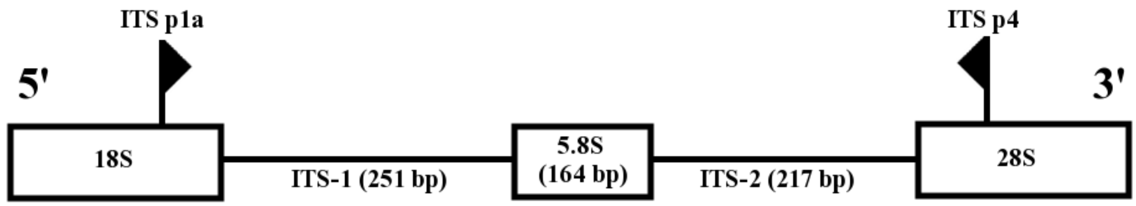


Figure 2.4: Schematic of a single ITS repeat (excluding ETS) in *Nama*. Regions of DNA corresponding to rRNA subunits are illustrated by boxes; internal transcribed spacer regions (ITS-1 and ITS-2) are illustrated with lines. Arrows above the 18S and 28S subunits show location of forward and reverse primers p1a and p4.

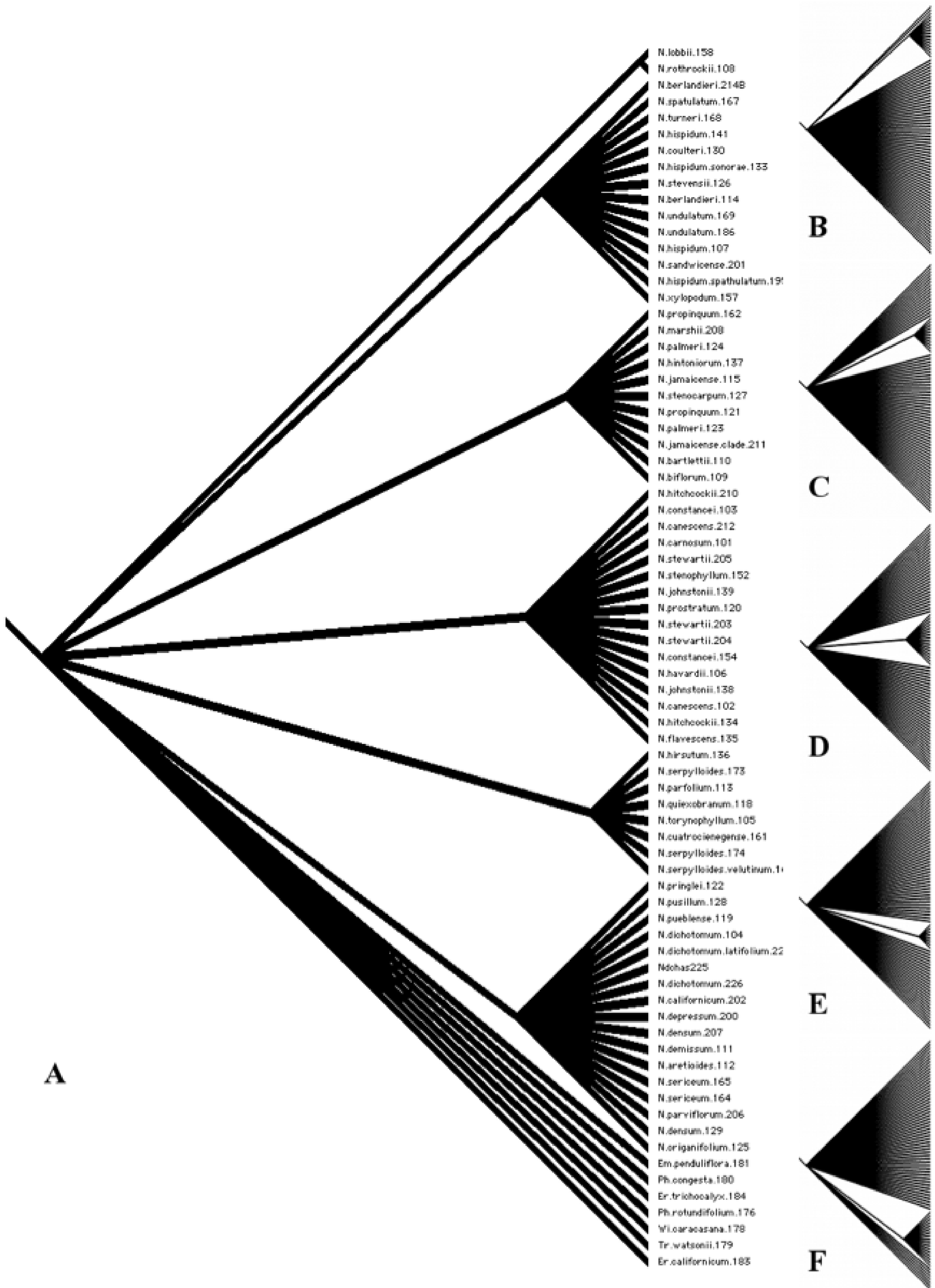
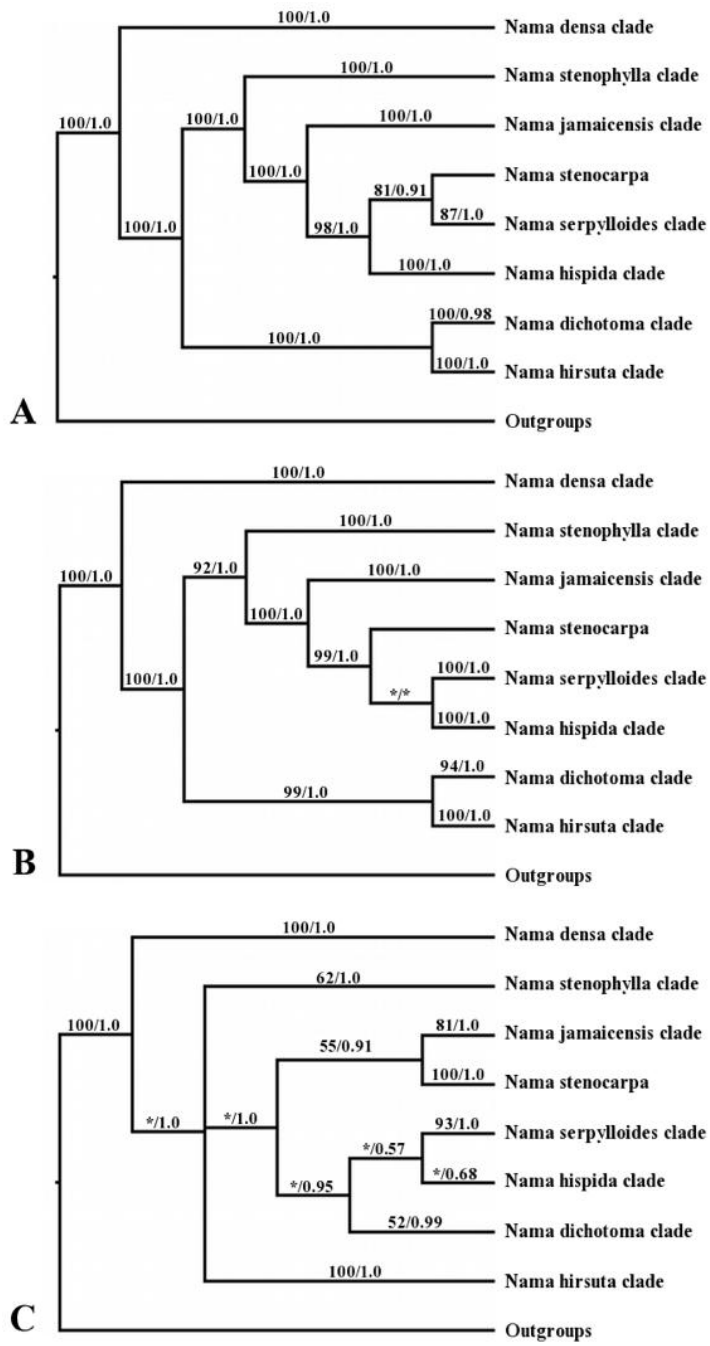


Figure 2.5. Constraint trees used to test the hypothetical monophyly of informal seed groups described by Chance and Bacon (1984). A. All seed groups. B. Seed group 2. C. Seed group 3. D. Seed group 4. E. Seed group 5. F. Seed group 6.

Figure 2.6.



100/1.0
Nama densa clade
Nama stenophylla clade
Nama jamaicensis clade
Nama stenocarpa
Nama serpylloides clade
Nama hispida clade
Nama dichotoma clade
Nama hirsuta clade
Outgroups
A
B
C

Figure 2.6: Relationships among the seven major clades of *Nama* recovered through analysis of chloroplast, ITS, and combined datasets. A. Chloroplast dataset (unpartitioned and partitioned) as analyzed by RAxML, GARLI, and MrBayes. B. Combined cp + ITS dataset as analyzed by GARLI and MrBayes. C. Consensus of best-scoring ML trees obtained through analyses of the ITS dataset by GARLI and RAxML. Branch support values given above branches indicate RAxML bootstrap percentages (or GARLI bootstrap percentages for the combined chloroplast + ITS data set) followed by Bayesian posterior probabilities. *Nama stenocarpa* was represented by a single species in the chloroplast and combined cp + ITS trees and by 5 clones in the ITS tree; therefore the branch leading to that species carries support values only in the ITS tree. Asterisks indicate support values below 50% or 0.5.

Figure 2.7.

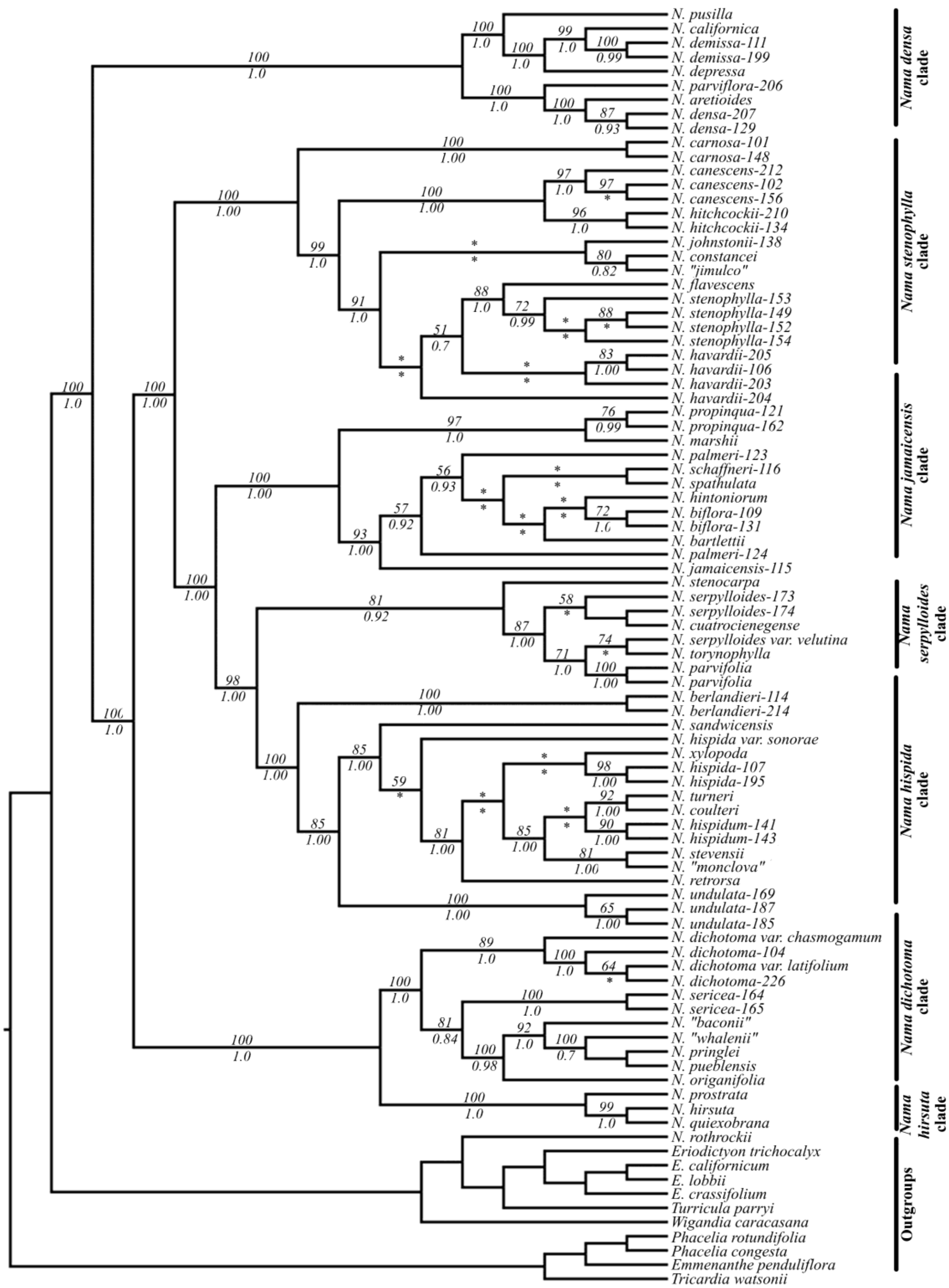

N. pusilla
N. californica
N. demissa-111
N. demissa-199
N. depressa
N. parviflora-206
N. aretioides
N. densa-207
N. densa-129
N. carnosa-101
N. carnosa-148
N. canescens-212
N. canescens-102
N. canescens-156
N. hitchcockii-210
N. hitchcockii-134
N. johnstonii-138
N. constancei
N. "jimulco"
N. flavescens
N. stenophylla-153
N. stenophylla-149
N. stenophylla-152
N. stenophylla-154
N. havardii-205
N. havardii-106
N. havardii-203
N. havardii-204
N. propinqua-121
N. propinqua-162
N. marshii
N. palmeri-123
N. schaffneri-116
N. spathulata
N. hintoniorum
N. biflora-109
N. biflora-131
N. bartlettii
N. palmeri-124
N. jamaicensis-115
N. stenocarpa
N. serpylloides-173
N. serpylloides-174
N. cuatrocienegense
N. serpylloides var. velutina
N. torynophylla
N. parvifolia
N. parvifolia
N. berlandieri-114
N. berlandieri-214
N. sandwicensis
N. hispida var. sonorae
N. xylopoda
N. hispida-107
N. hispida-195
N. turneri
N. coulteri
N. hispidum-141
N. hispidum-143
N. stevensii
N. "monclova"
N. retrorsa
N. undulata-169
N. undulata-187
N. undulata-185
N. dichotoma var. chasmogamum
N. dichotoma-104
N. dichotoma var. latifolium
N. dichotoma-226
N. sericea-164
N. sericea-165
N. "baconii"
N. "whalenii"
N. pringlei
N. pueblensis
N. origanifolia
N. prostrata
N. hirsuta
N. quiexobrana
N. rothrockii
Eriodictyon trichocalyx
E. californicum
E. lobbii
E. crassifolium
Turricula parryi
Wigandia caracasana
Phacelia rotundifolia
Phacelia congesta
Emmenanthe penduliflora
Tricardia watsonii
Nama densa clade
Nama stenophylla clade
Nama jamaicensis clade
Nama serpylloides clade
Nama hispida clade
Nama dichotoma clade
Nama hirsuta clade
Outgroups

Figure 2.7: Chloroplast phylogeny of *Nama* reconstructed using both maximum likelihood (RAxML, GARLI) and Bayesian (MrBayes) optimality criteria. Partitioned and unpartitioned analyses yielded identical topologies. Numbers above branches are bootstrap values obtained from RAxML (bootstrap values from GARLI were 0-5 percentage points lower). Numbers below branches are Bayesian posterior probabilities. Asterisks indicate support values below 50% or 0.5.

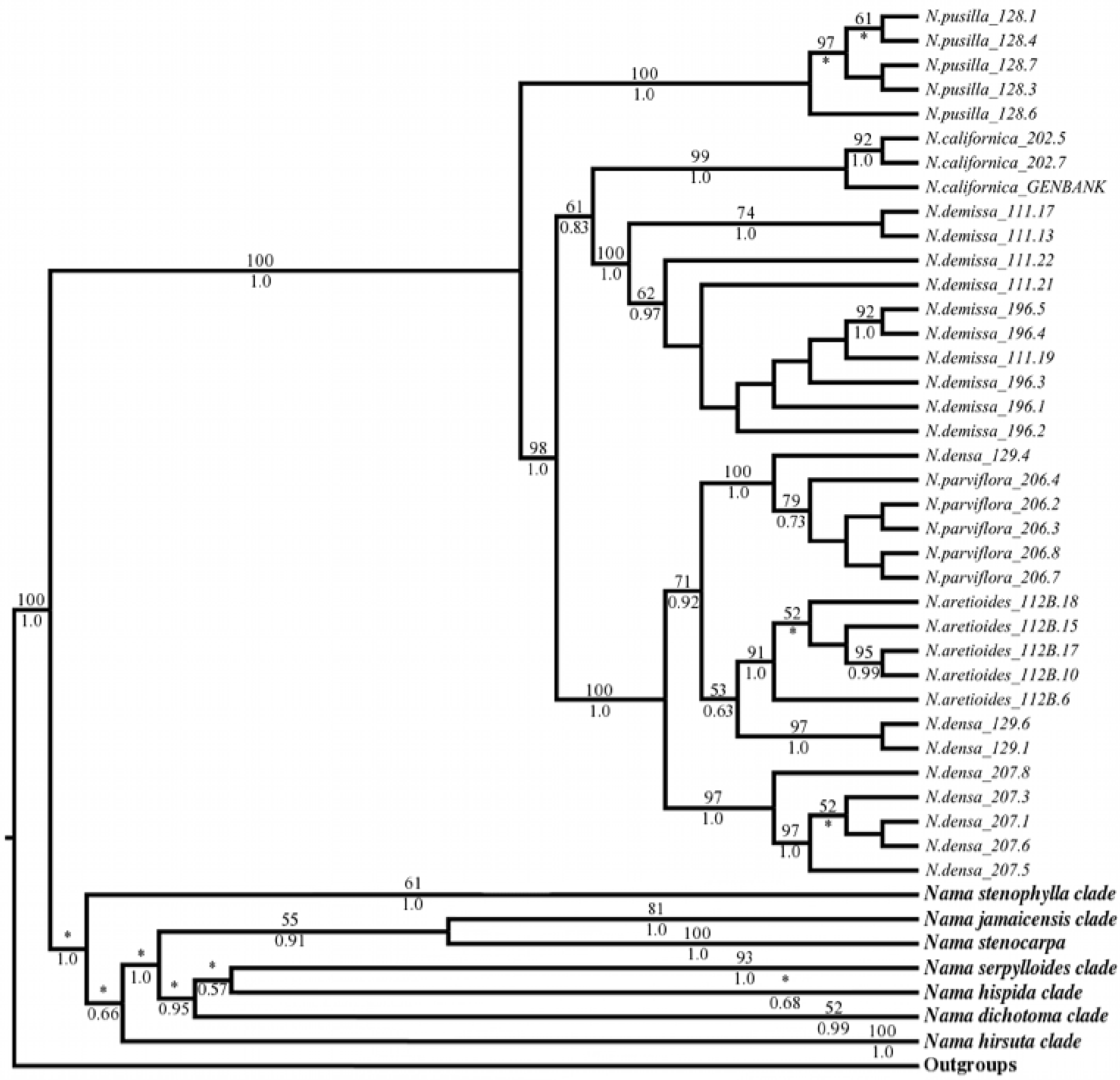


Figure 2.8: *Nama densa* clade from the best-scoring ML tree obtained from RAxML analyses of ITS. Numbers above branches indicate bootstrap values from a partitioned analysis of ITS (18S subunit, ITS-1, 5.8S subunit, ITS-2, and 28S subunit partitions); bootstrap values obtained from unpartitioned analyses using GARLI were slightly lower. Numbers below branches are posterior probabilities from Bayesian analysis of the ITS dataset. Asterisks indicate support values below 50% or 0.5.

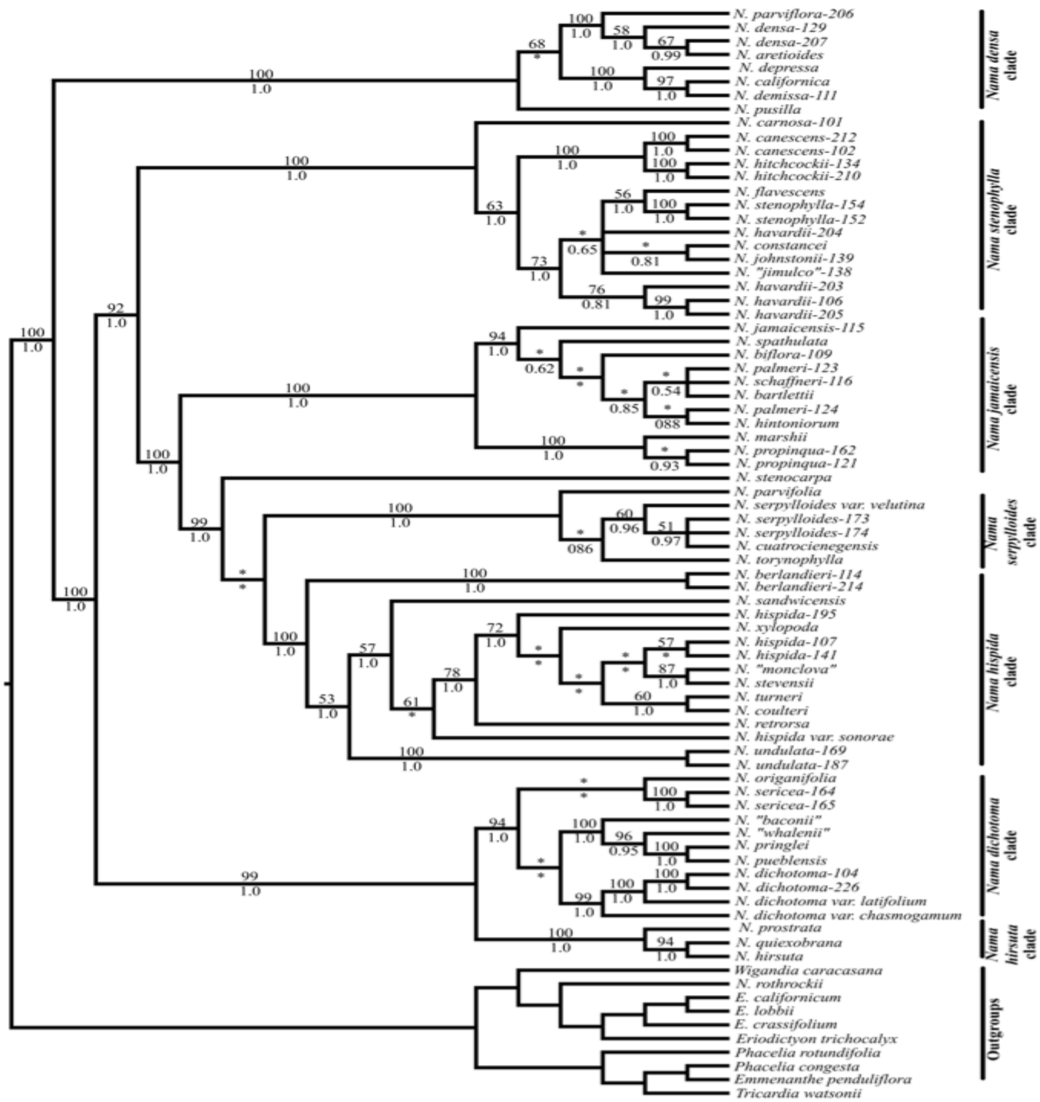


Figure 2.9: Combined chloroplast and ITS phylogeny of *Nama* reconstructed using both maximum likelihood (GARLI) and Bayesian (MrBayes) optimality criteria. Partitioned and unpartitioned analyses yielded identical topologies. Numbers above branches are bootstrap values obtained from GARLI. Numbers below branches are Bayesian posterior probabilities. Asterisks indicate support values below 50% or 0.5.

Figure 2.10.

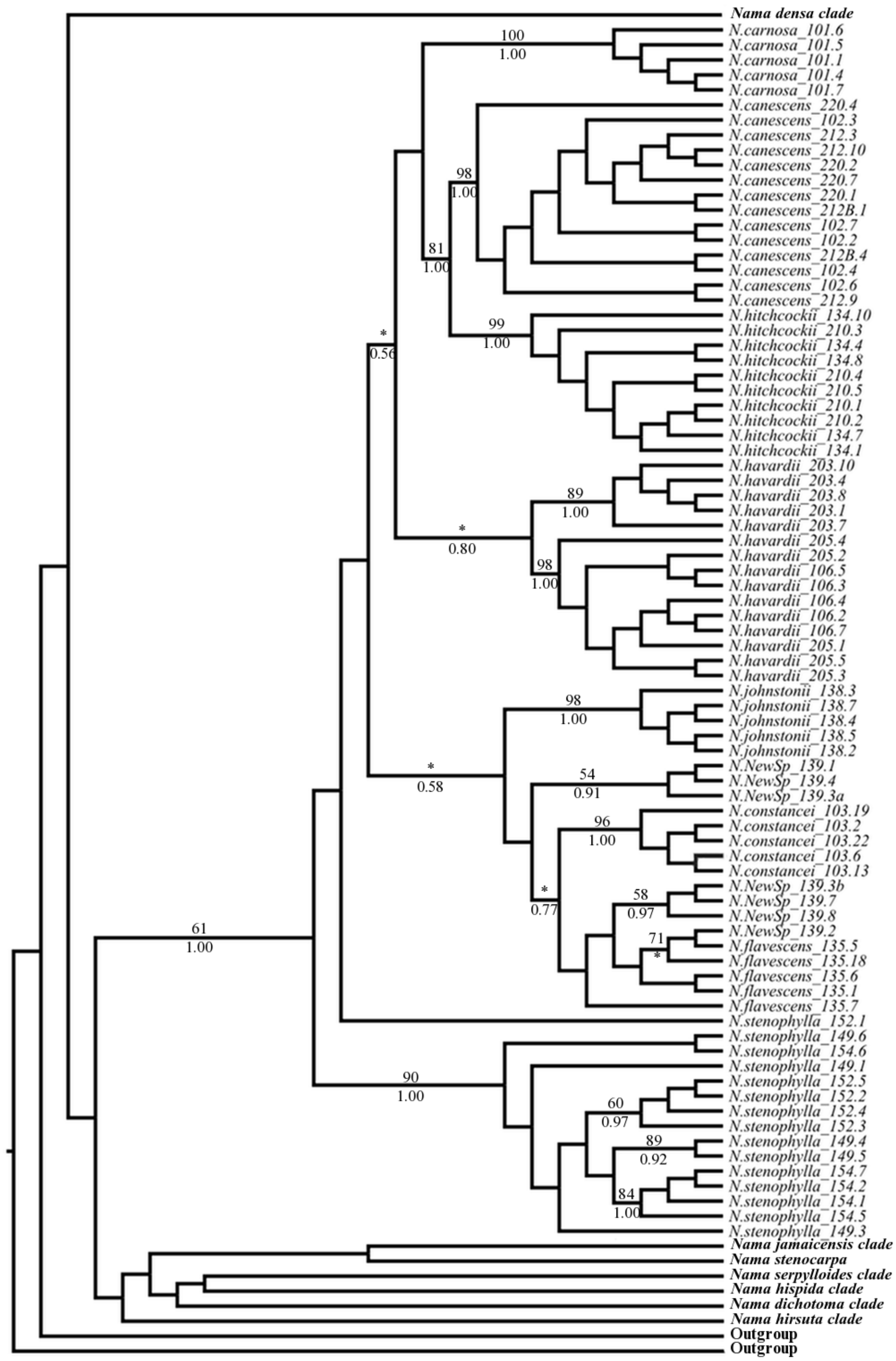

Nama densa clade
N.carnosa_101.6
N.carnosa_101.5
N.carnosa_101.1
N.carnosa_101.4
N.carnosa_101.7
N.canescens_220.4
N.canescens_102.3
N.canescens_212.3
N.canescens_212.10
N.canescens_220.2
N.canescens_220.7
N.canescens_220.1
N.canescens_212B.1
N.canescens_102.7
N.canescens_102.2
N.canescens_212B.4
N.canescens_102.4
N.canescens_102.6
N.canescens_212.9
N.hitchcockii_134.10
N.hitchcockii_210.3
N.hitchcockii_134.4
N.hitchcockii_134.8
N.hitchcockii_210.4
N.hitchcockii_210.5
N.hitchcockii_210.1
N.hitchcockii_210.2
N.hitchcockii_134.7
N.hitchcockii_134.1
N.havardii_203.10
N.havardii_203.4
N.havardii_203.8
N.havardii_203.1
N.havardii_203.7
N.havardii_205.4
N.havardii_205.2
N.havardii_106.5
N.havardii_106.3
N.havardii_106.4
N.havardii_106.2
N.havardii_106.7
N.havardii_205.1
N.havardii_205.5
N.havardii_205.3
N.johnstonii_138.3
N.johnstonii_138.7
N.johnstonii_138.4
N.johnstonii_138.5
N.johnstonii_138.2
N.NewSp_139.1
N.NewSp_139.4
N.NewSp_139.3a
N.constancei_103.19
N.constancei_103.2
N.constancei_103.22
N.constancei_103.6
N.constancei_103.13
N.NewSp_139.3b
N.NewSp_139.7
N.NewSp_139.8
N.NewSp_139.2
N.flavescens_135.5
N.flavescens_135.18
N.flavescens_135.6
N.flavescens_135.1
N.flavescens_135.7
N.stenophylla_152.1
N.stenophylla_149.6
N.stenophylla_154.6
N.stenophylla_149.1
N.stenophylla_152.5
N.stenophylla_152.2
N.stenophylla_152.4
N.stenophylla_152.3
N.stenophylla_149.4
N.stenophylla_149.5
N.stenophylla_154.7
N.stenophylla_154.2
N.stenophylla_154.1
N.stenophylla_154.5
N.stenophylla_149.3
Nama jamaicensis clade
Nama stenocarpa
Nama serpylloides clade
Nama hispida clade
Nama dichotoma clade
Nama hirsuta clade
Outgroup
Outgroup

Figure 2.10: *Nama stenophylla* clade from the ITS Maximum Likelihood tree obtained from RAxML. Numbers above branches indicate bootstrap values from a partitioned analysis of ITS (18S subunit, ITS-1, 5.8S subunit, ITS-2, and 28S subunit partitions); bootstrap values obtained from unpartitioned analyses using RAxML and GARLI were slightly lower. Numbers below branches are posterior probabilities from Bayesian analysis of the ITS dataset. Asterisks indicate support values below 50% or 0.5.

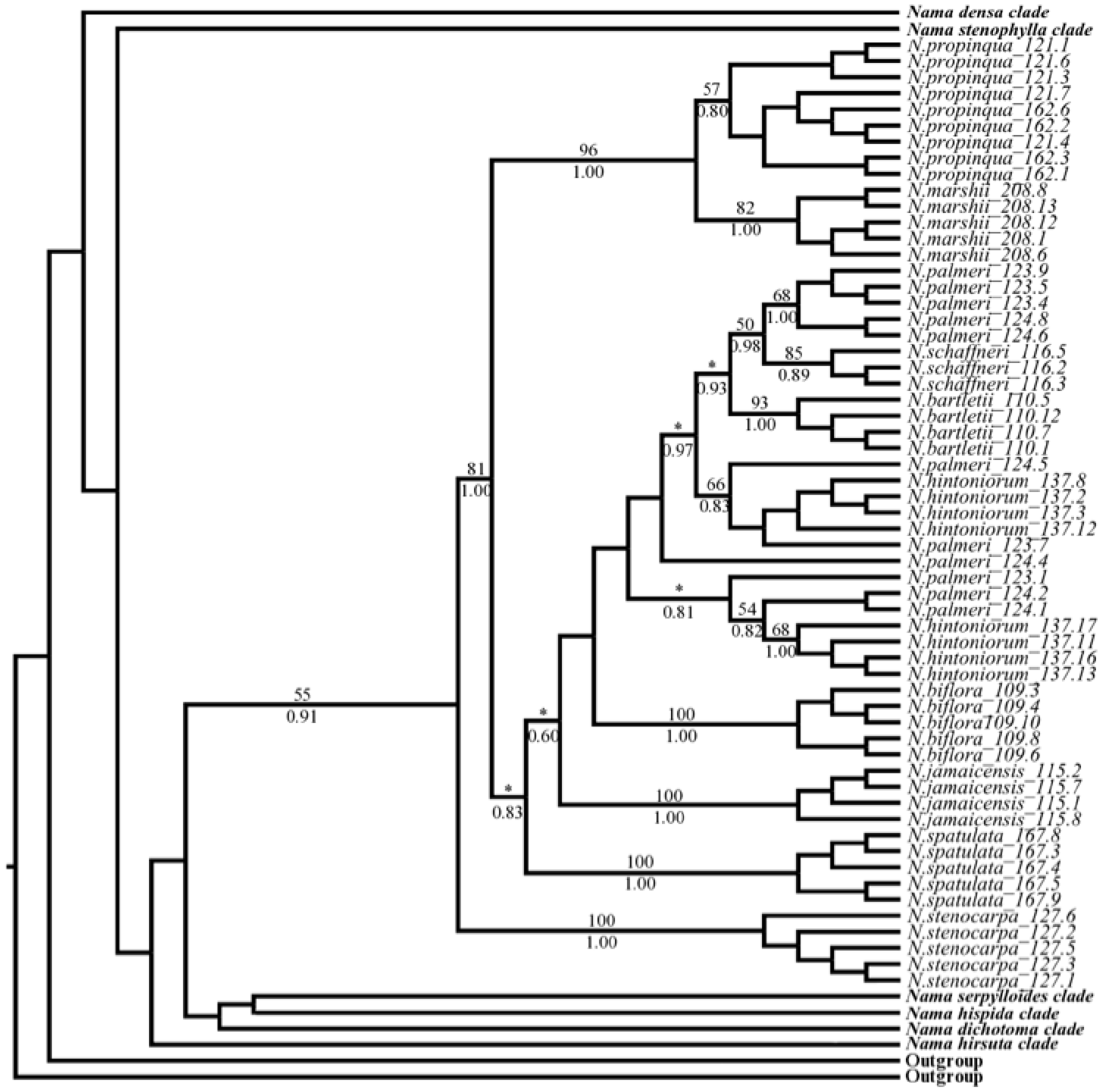


Figure 2.11: *Nama jamaicensis* clade plus *N. stenocarpa* from the ITS Maximum Likelihood tree obtained from RAxML. Numbers above branches indicate bootstrap values from a partitioned analysis of ITS (18S subunit, ITS-1, 5.8S subunit, ITS-2, and 28S subunit partitions); bootstrap values obtained from unpartitioned analyses using RAxML and GARLI were slightly lower. Numbers below branches are posterior probabilities from Bayesian analysis of the ITS dataset. Asterisks indicate support values below 50% or 0.5.

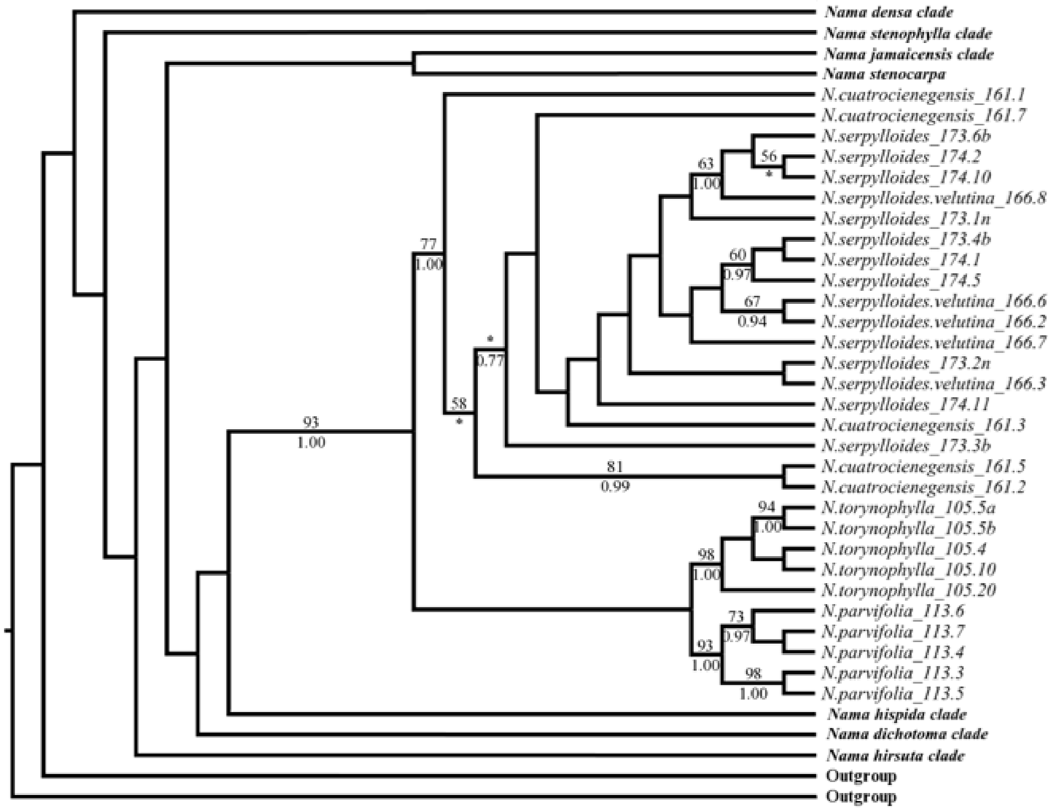


Figure 2.12: *Nama serpylloides* clade from the ITS Maximum Likelihood tree obtained from RAxML. Numbers above branches indicate bootstrap values from a partitioned analysis of ITS (18S subunit, ITS-1, 5.8S subunit, ITS-2, and 28S subunit partitions); bootstrap values obtained from unpartitioned analyses using RAxML and GARLI were slightly lower. Numbers below branches are posterior probabilities from Bayesian analysis of the ITS dataset. Asterisks indicate support values below 50% or 0.5.

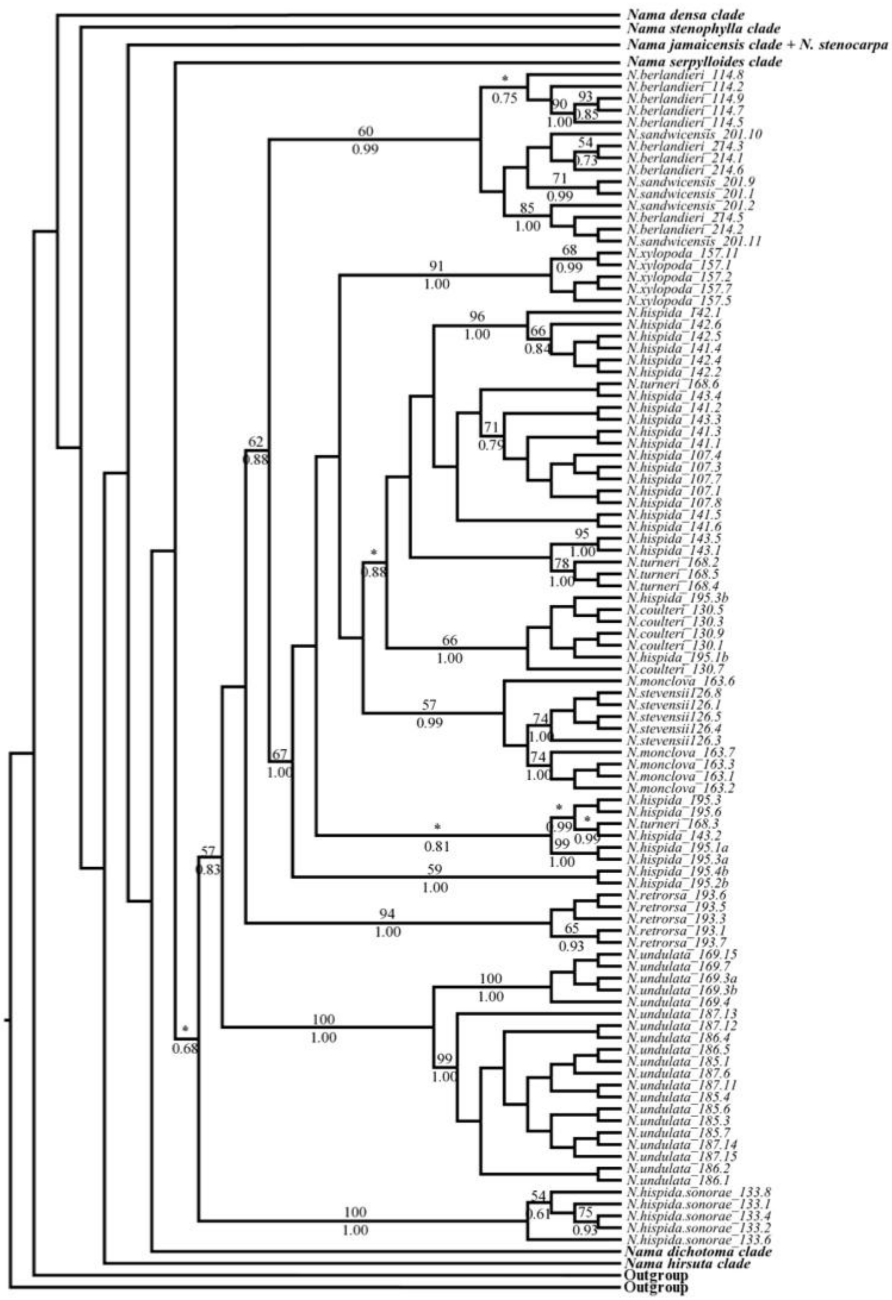


Figure 2.13: *Nama hispida* clade from the ITS Maximum Likelihood tree obtained from RAxML. Numbers above branches indicate bootstrap values from a partitioned analysis of ITS (18S subunit, ITS-1, 5.8S subunit, ITS-2, and 28S subunit partitions); bootstrap values obtained from unpartitioned analyses using RAxML and GARLI were slightly lower. Numbers below branches are posterior probabilities from Bayesian analysis of the ITS dataset. Asterisks indicate support values below 50% or 0.5.

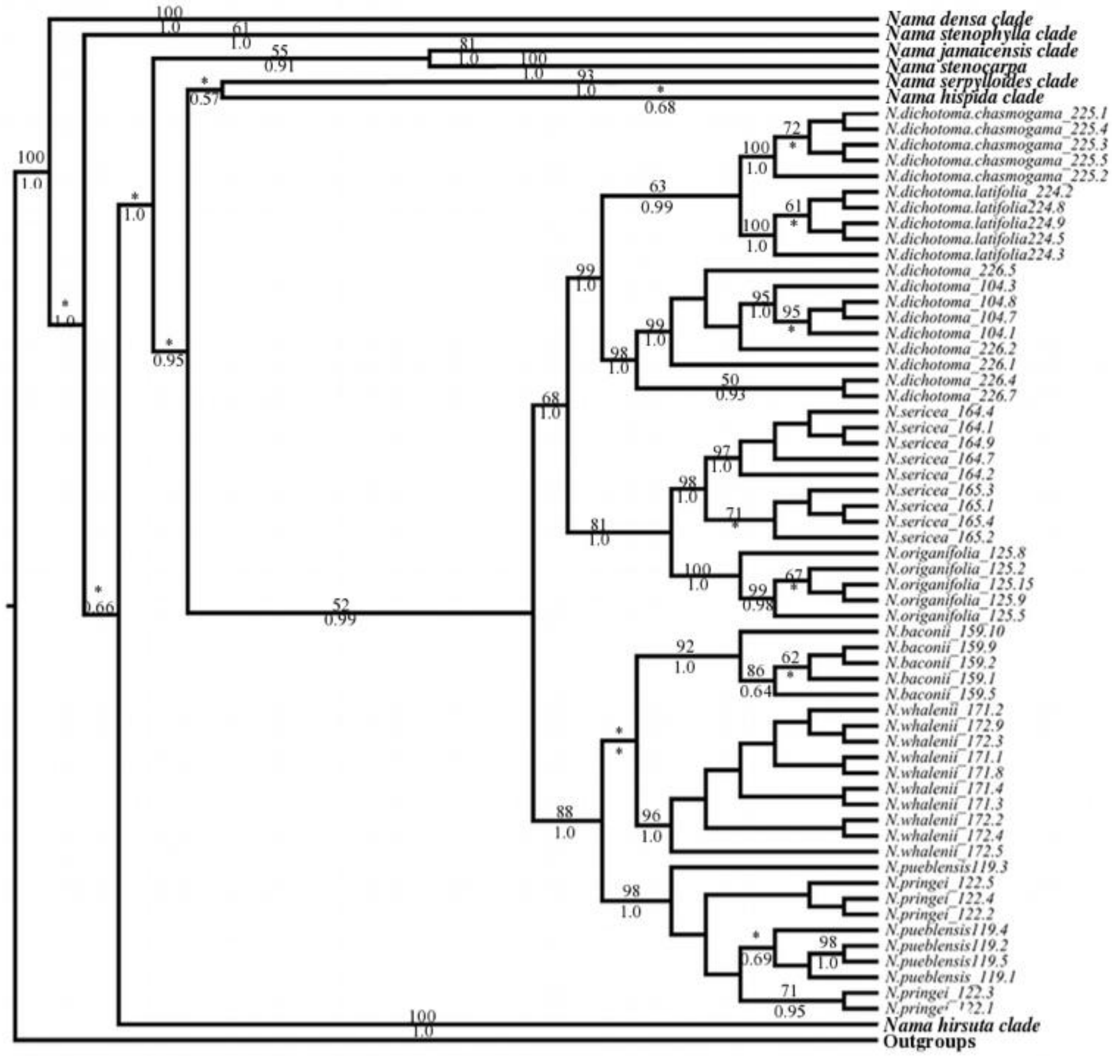


Figure 2.14: *Nama dichotoma* clade from the ITS Maximum Likelihood tree obtained from RAxML. Numbers above branches indicate bootstrap values from a partitioned analysis of ITS (18S subunit, ITS-1, 5.8S subunit, ITS-2, and 28S subunit partitions); bootstrap values obtained from unpartitioned analyses using RAxML and GARLI were slightly lower. Numbers below branches are posterior probabilities from Bayesian analysis of the ITS dataset. Asterisks indicate support values below 50% or 0.5.

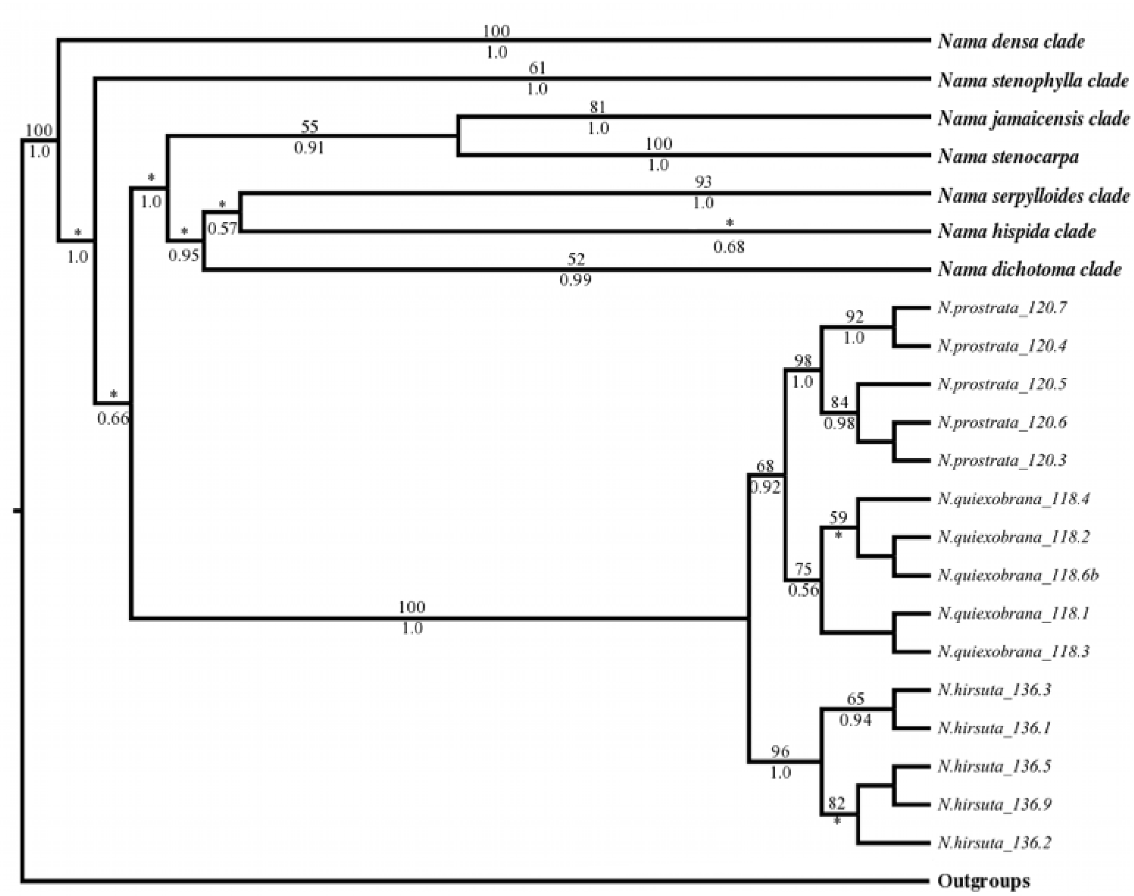


Figure 2.15: *Nama hirsuta* clade from the ITS Maximum Likelihood tree obtained from RAxML. Numbers above branches indicate bootstrap values from a partitioned analysis of ITS (18S subunit, ITS-1, 5.8S subunit, ITS-2, and 28S subunit partitions); bootstrap values obtained from unpartitioned analyses using RAxML and GARLI were slightly lower. Numbers below branches are posterior probabilities from Bayesian analysis of the ITS dataset. Asterisks indicate support values below 50% or 0.5.

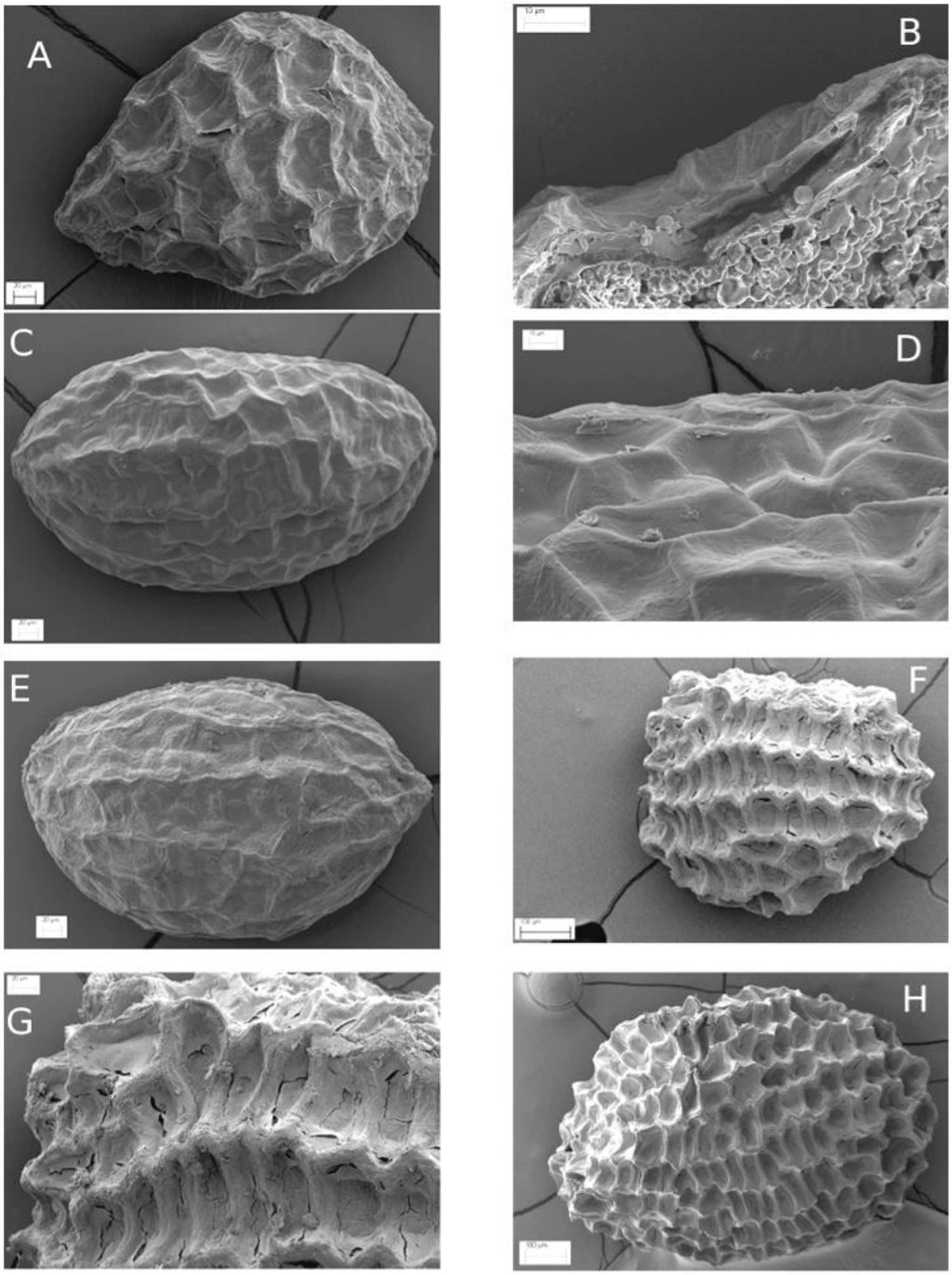


Figure 2.16: Scanning electron micrographs of seeds in Seed Group 2 and Seed Group 3. Seed Group 2: A. *Nama berlandieri*, whole seed. B. *N. berlandieri*, cross-section showing solid testa. C. *N. coulteri*, whole seed. D. *N. coulteri*, close-up of surface. E. *N. xylopoda*, whole seed. Seed Group 3: F. *N. biflora*, whole seed. G. *N. biflora*, close-up of surface. H. *N. spathulata*, whole seed.

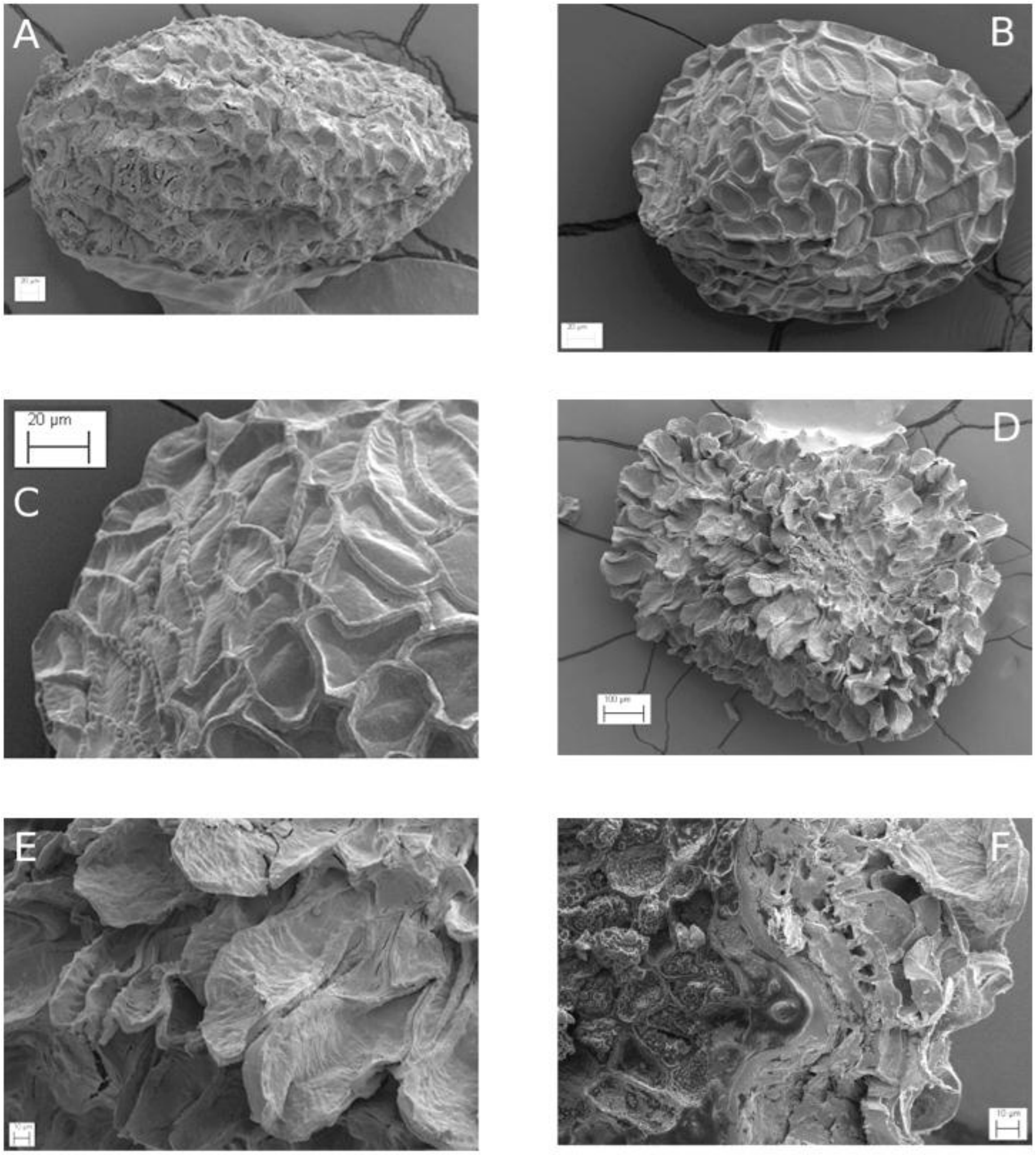


Figure 2.17: Scanning electron micrographs of seeds in Seed Group 4 and Seed Group 5. Seed Group 4: A. *Nama havardii*, whole seed. Seed Group 5: B. *N. cuatrocienegensis*, whole seed. C. *N. cuatrocienegensis*, close-up of seed surface showing U-shaped thickenings across reticula. D. *N. quiexobrana*, whole seed. E. *N. quiexobrana*, close-up of surface showing U-shaped thickenings on scales. F. *N. quiexobrana*, cross-section with arrow indicating pores in reticulum cell wall.

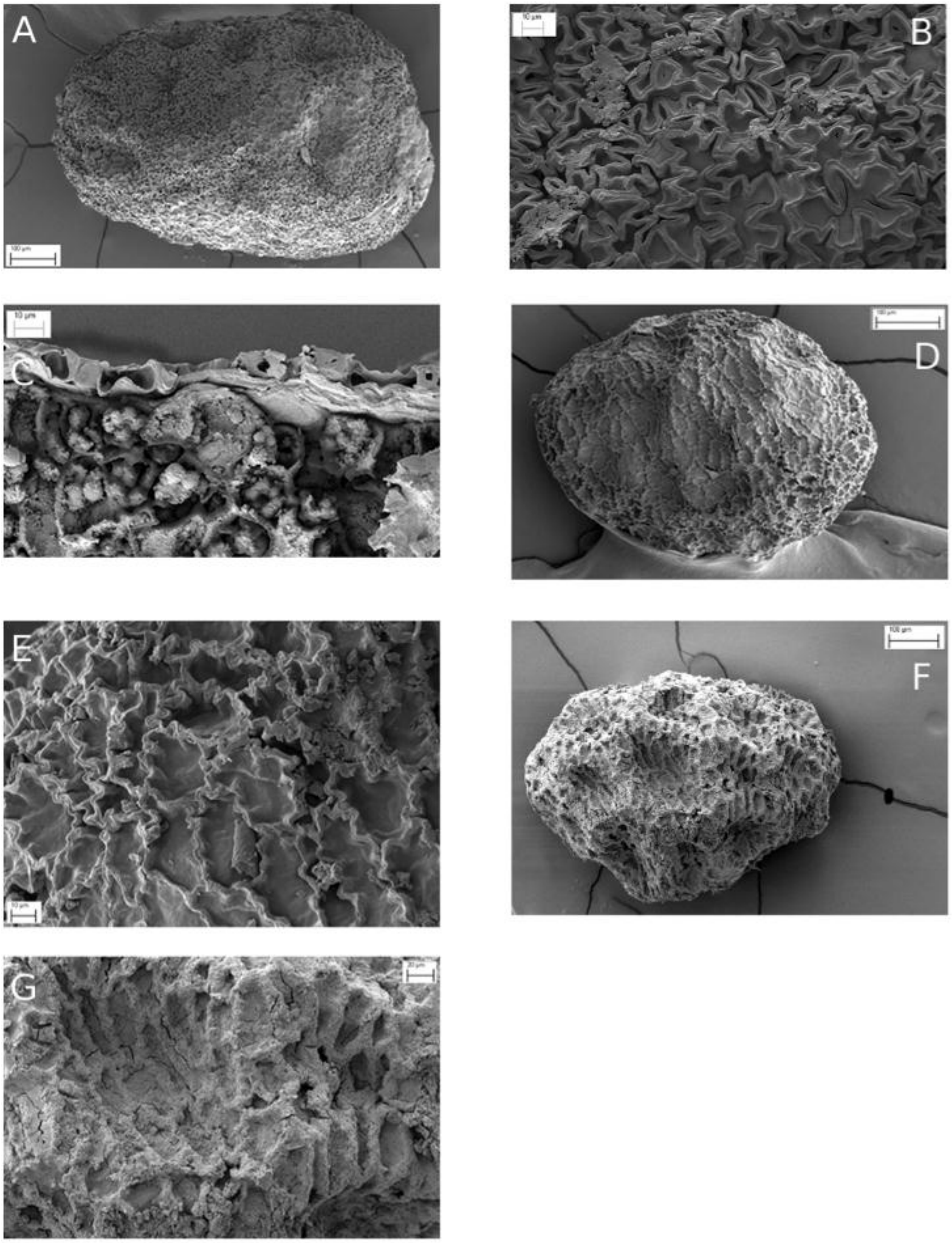


Figure 2.18: Scanning electron micrographs of seeds in Seed Group 6. A. *Nama californica*, whole seed. B. *N. californica*, close-up of seed surface. C. *N. californica*, cross section showing pores in reticulum cell walls. D. *N. pringlei*, whole seed. E. *N. pringlei*, close-up of seed surface. F. *N. pueblensis*, whole seed. G. *N. pueblensis*, close-up of seed surface.

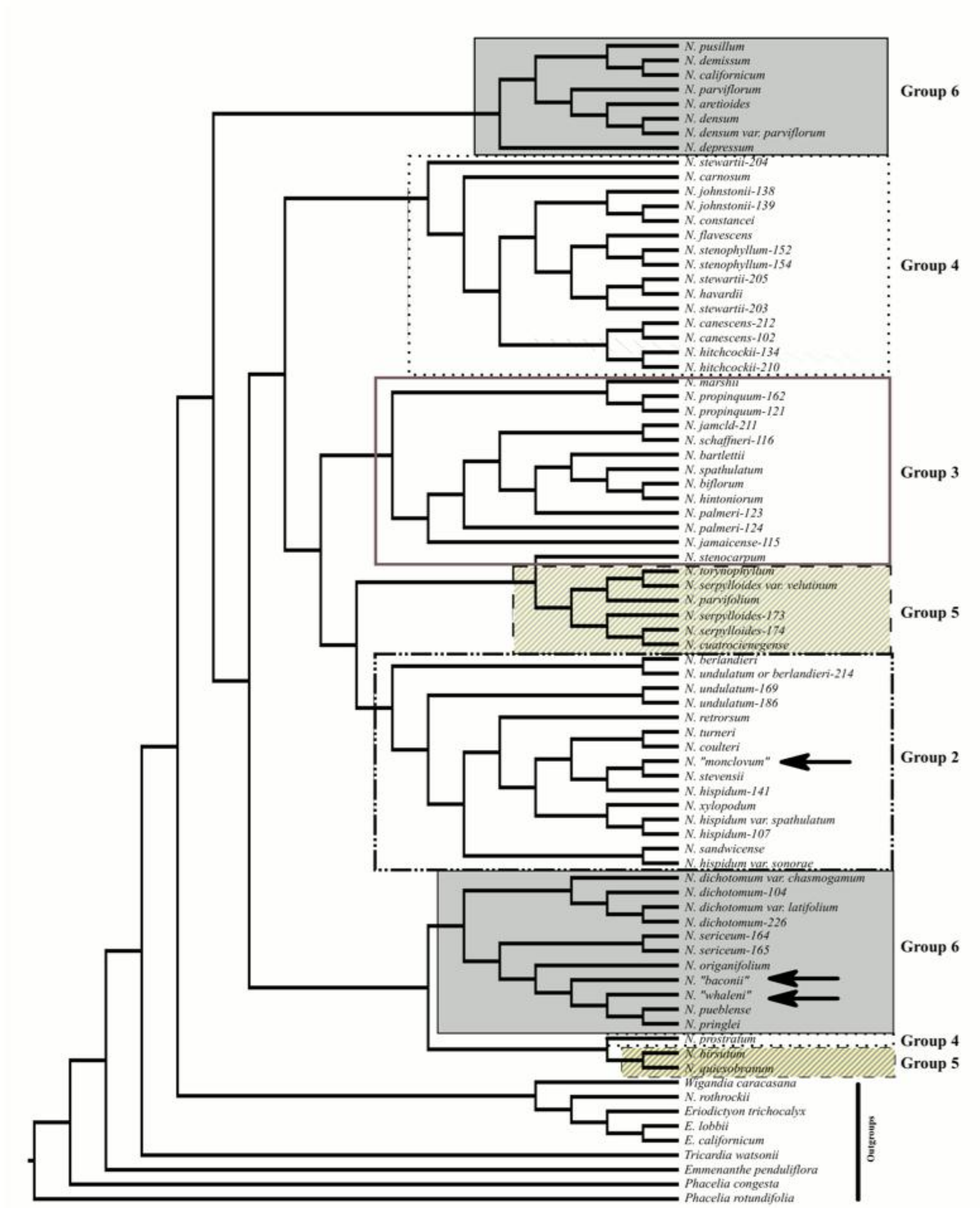


Figure 2.19: Seed groups as delineated by Chance and Bacon (1984) mapped onto the chloroplast phylogeny. Arrows indicate positions of undescribed putative species, which were not examined by SEM.

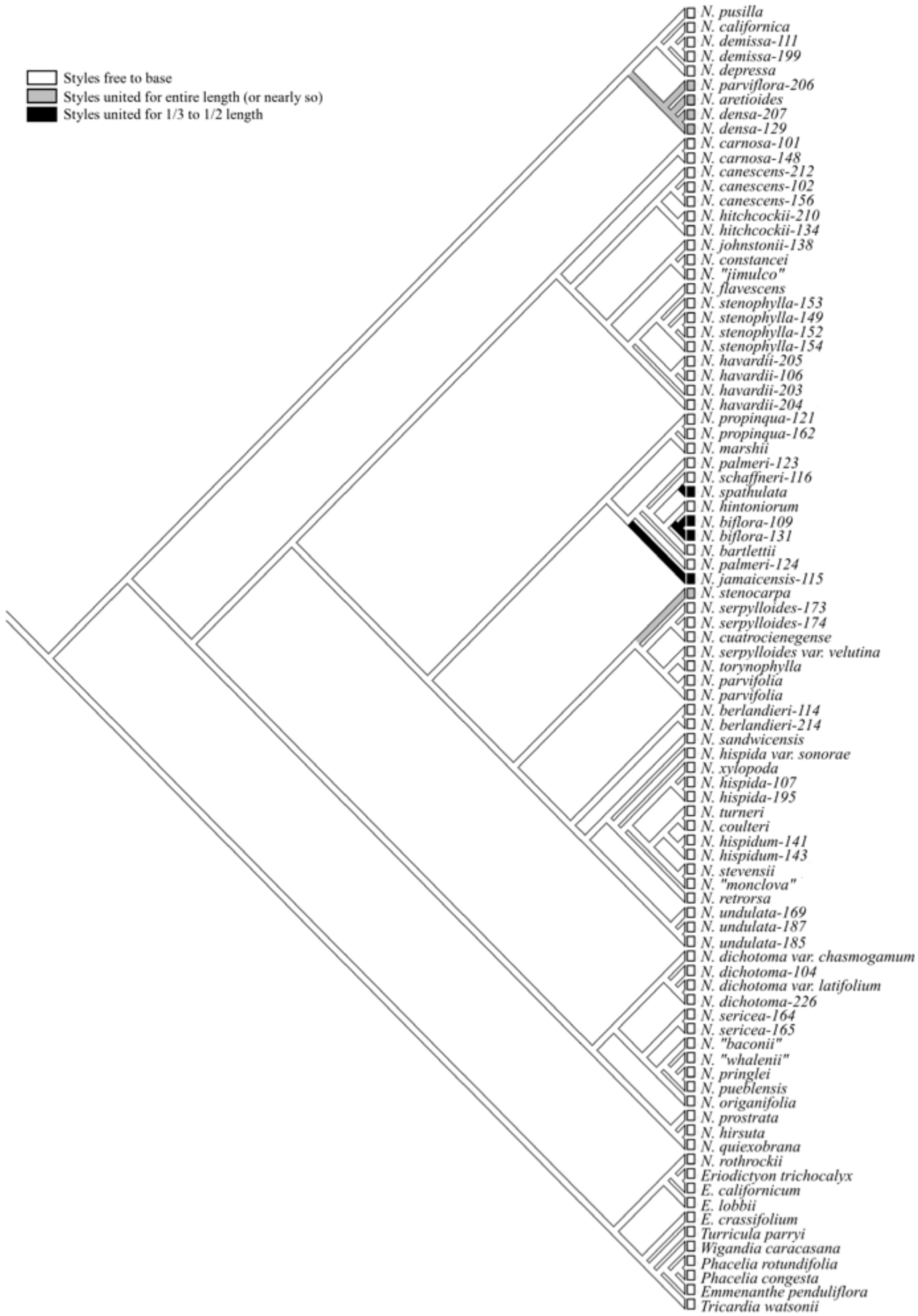


Figure 2.20: Single most parsimonious ancestral states reconstruction of the degree of style fusion mapped on to the best-scoring ML tree for the chloroplast data set.

Figure 2.21.


Section Paleonama: free portion shorter than adnate portion.
Section Neonama: free portion longer than adnate portion.
N. pusilla
N. californica
N. demissa-111
N. demissa-199
N. depressa
N. parviflora-206
N. aretioides
N. densa-207
N. densa-129
N. carnosa-101
N. carnosa-148
N. canescens-212
N. canescens-102
N. canescens-156
N. hitchcockii-210
N. hitchcockii-134
N. johnstonii-138
N. constancei
N. "jimulco"
N. flavescens
N. stenophylla-153
N. stenophylla-149
N. stenophylla-152
N. stenophylla-154
N. havardii-205
N. havardii-106
N. havardii-203
N. havardii-204
N. propinqua-121
N. propinqua-162
N. marshii
N. palmeri-123
N. schaffneri-116
N. spathulata
N. hintoniorum
N. biflora-109
N. biflora-131
N. bartlettii
N. palmeri-124
N. jamaicensis-115
N. stenocarpa
N. serpylloides-173
N. serpylloides-174
N. cuatrocienegense
N. serpylloides var. velutina
N. torynophylla
N. parvifolia
N. parvifolia
N. berlandieri-114
N. berlandieri-214
N. sandwicensis
N. hispida var. sonorae
N. xylopoda
N. hispida-107
N. hispida-195
N. turneri
N. coulteri
N. hispidum-141
N. hispidum-143
N. stevensii
N. "monclova"
N. retrorsa
N. undulata-169
N. undulata-187
N. undulata-185
N. dichotoma var. chasmogamum
N. dichotoma-104
N. dichotoma var. latifolium
N. dichotoma-226
N. sericea-164
N. sericea-165
N. "baconii"
N. "whalenii"
N. pringlei
N. pueblensis
N. origanifolia
N. prostrata
N. hirsuta
N. quiexobrana
N. rothrockii
Eriodictyon trichocalyx
E. californicum
E. lobbii
E. crassifolium
Turricula parryi
Wigandia caracasana
Phacelia rotundifolia
Phacelia congesta
Emmenanthe penduliflora
Tricardia watsonii

Figure 2.21: ACCTRAN ancestral states reconstruction of the proportion of anther filament length that is adnate to the corolla mapped on to the best-scoring ML tree for the chloroplast data set. Dark lines indicate that the free portion is shorter than the adnate portion (Brand's [1913] Section *Neonama*); white lines indicate that the free portion is longer than the adnate portion (Brand's Section *Paleonama*). Inset illustrates DELTRAN reconstruction of the same character.

Chapter 3: Evolutionary origins of gypsophily in *Nama* (Boraginaceae) within the Chihuahuan Desert Region

INTRODUCTION

The earliest known published correlation between soil types and plant communities dates to 1789 (Kruckeberg 2002), when Heinrich Friedrich Link, at the time a 22-year old medical student, published his thesis on the flora of rocky outcrops around Göttingen, Germany. In the very earliest pages, he noted differences in vegetation occurring on limestone, sand, and clay soils, remarking, "However, when mountains of limestone and equally of sand show a special natural characteristic, you will also find certain plants that never cross from a mountain of limestone to sand."(Link 1790; translation by Emily Goetz). The subsequent study of edaphic endemism, or the restriction of plants and animals to certain chemical, physical, and biological characteristics of soils, has yielded long lists of unique substrate types and taxa that are endemic to them. Distinctive floras with high numbers of endemic taxa have been documented from substrates as diverse as granite, shale, limestone, serpentine, salt flats, seabird guano deposits, and heavy metal-rich mine tailings (Mason 1946b, Gankin and Major 1964, Jain and Bradshaw 1966, McNeilly and Bradshaw 1967, Kruckeberg 1969, Ornduff 1965, Bradshaw and McNeilly 1981, Kruckeberg and Rabinowicz 1985, Anderson et al. 1999, Rajakaruna 2004). Gypsum (hydrous calcium sulfate, $CaSO_4$*$2H_2O$) outcrops are likewise associated with unique floras that are rich in endemic species (Powell and Turner 1977, Turner and Powell 1979, Kruckeberg and Rabinowicz 1985, Meyer 1986, Mota et al. 2004, Palacio et al. 2007, Bogdanovic et al. 2009), although much remains unknown about these communities (Meyer 1986, Meyer et al. 1992, Escudero et al. 1999, Palacio et al. 2007).

A variety of terms have been coined to describe taxa that exhibit varying levels of fidelity to gypsum, with frequent distinction between taxa that appear to require gypsum and those that tolerate gypsum but may grow on other substrates, such as limestone or sandy soils (Johnston 1941, Duvigneaud and Denaeyer-De Smet 1968; Parsons 1976, Meyer 1986, Mota et al. 2009). Terminology here will follow that of Parsons (1976): "obligate gypsophile" will refer to those species and varieties collected exclusively from gypsum deposits and therefore presumably require it, and "facultative gypsophile" to those that have been recorded from both gypsum deposits and non-gypsum soils. "Gypsophile" or "gypsophilous" without a modifier will refer to obligate and facultative gypsophiles collectively. "Non-gypsophile" will refer to taxa that have not been collected or otherwise recorded from gypseous soils.

Gypsum beds are formed through precipitation and sedimentation in a saline body of water that subsequently evaporates (Murray 1964). Anhydrite ($CaSO_4$) forms from gypsum when all water is removed from its crystal structure; weathering and hydration of anhydrite converts the mineral back to gypsum. Anhydrite and gypsum occur worldwide, with gypsosols (soils with 5 percent or more gypsum by volume; IUSS Working Group 2006) covering more than 100 million hectares globally (Verheye and Boyadgiev 1997, IUSS Working Group 2006). Because gypsum is moderately soluble, outcrops are only found in arid and semi-arid climates (WRB 1990). Gypsum is most commonly observed as coarse-grained rock gypsum but also occurs as fine-grained alabaster, crystalline selenite, caliche-like gypsite, or dune-forming sands (Nettleton et al. 1982; Weber and Kottlowski 1959). Gypsum usually ranges from white to dark gray but is sometimes red to brown or pink (Weber and Kottlowski 1959), and can be distinguished from limestone in the field by the characteristic hollow sound it emits when tapped (Johnston 1941).

Within the Chihuahuan Desert Region (Figure 3.1), anhydrite and gypsum deposits range from Permian outcroppings of bedded gypsum intermixed with sedimentary redbed in west Texas and eastern New Mexico (Weber and Kottlowski 1959, Johnson et al. 1989), to exposed gypsum deposits in north-central Mexico produced by sedimentation in, and evaporation of, Upper Jurassic and Lower Cretaceous seas and inland saline lakes (Humphrey and Diaz 2003, Weber and Kottlowski 1959, Turner and Powell 1979), to the Quaternary-aged White Sands gypsum dunes of the Tularosa Basin in New Mexico derived from Pleistocene dry lake beds (Weber and Kottlowski 1959, Nettleton et al. 1982). Outcrops range in size from less than 100 square meters to over 100 square kilometers and are arrayed patchily across the desert, dotting the landscape in an island-like fashion (Powell and Turner 1977, Shields 1956). These gypsum "islands" are subject to faster rates of erosion than surrounding limestone substrates (Turner and Powell 1979) as well as varying degrees of isolation, which can reduce the amount of gene flow between populations and potentially lead to speciation (Mayr 1942, Dobzhanski 1941, McNeilly and Antonovics 1967, Kruckeberg and Rabinowicz 1985). Gene flow between outcrops is reliant upon long-distance dispersal potentially including (but not limited to) rainwater runoff, wind, dust devils, or transport in mud on bird feet (Powell and Turner 1977, Henrickson 1977). Estimates of total gypsum cover within the Chihuahuan Desert Region are unavailable, although gypsosols account for 400,000 ha in the Mexican state of San Luis Potosi alone (Martinez-Montoya 2010). Gypsophilous scrub (Matorral Gipsófilo) covers approximately 2% of the total Chihuahuan Desert Region (Henrickson and Johnston 1986).

Unlike other soil types that harbor endemic species (e.g., serpentine deposits), gypsum deposits are typically not enriched with minerals other than the gypsum itself. While both chemical and physical properties of gypsosols have been hypothesized to be selective factors regulating gypsophily, Meyer (1986) found no evidence supporting a chemical basis for the presence or absence of gypsophiles on a given substrate. The tough crusts that characterize gypsum soils may be a main factor affecting germination success by inhibiting seedling establishment of non-gypsophilous species (Johnston 1941; Bridges and Burnham 1980; Meyer 1986; Borselli et al. 1996; Escudero et al. 2000). In addition, sponge gypsum (gypsum-rich soils with a low bulk density) may act as an effective insulator that keeps temperatures cool under the soil surface, thus slowing water loss and improving water availability to gypsophiles during dry periods (Meyer 1986).

The field of gypsum floristics has a long history in Europe, where the study of gypsophily can be traced to Cavanilles's (1795) observations on the natural history of the Iberian Peninsula (Mota et al. 2009). However, the phenomenon remained unstudied in the New World until the twentieth century. Beginning in the 1930s, botanists surveying the White Sands in New Mexico began to document specialized floras occurring in gypsum-rich soils (Emerson 1935, Campbell and Campbell 1938). Hitchcock (1939), as part of his revision of *Nama* (Boraginaceae), distinguished between *Nama stenophylla* A. Gray ex Hemsl. and *N. johnstonii* C.L. Hitchcock based partly on the observation that the former grows only on gypsum and the latter is restricted to limestone cliffs. Building on these early observations and inspired by a collecting trip through northern Mexico, Johnston (1941a, b) produced a landmark study demonstrating that species from widely separated gypsum deposits in the Chihuahuan Desert had several of the same associates, concluding that these gypsum assemblages were not due to chance local association or the individual preference of a small number of species. Due in large part to the influence of Johnston's work, interest in the floristics of gypsum outcrops in the Chihuahuan Desert Region has steadily increased over the last 70 years (Waterfall 1946, Shields 1956, Parsons 1976, Henrickson 1976, Turner and Powell 1977, Powell and Turner 1979, Bacon 1981, Henrickson and Johnston 1986). New species that are endemic to gypsum continue to be identified (e.g., Averett and Powell 1976, Henrickson 1976, Turner 1973, 1983, 2008, Nesom 1992a,b, 1993, Moore 2006). Given the remote nature and unexplored status of many gypsum outcrops in the Chihuahuan Desert Region it is likely that additional gypsum endemics will be described from the region (Parsons 1976).

Two factors complicate the enumeration of gypsophiles (and edaphic endemics in general). First, gypsum can be difficult to identify in the field, requiring some experience to distinguish it from other soil types (Henrickson and Johnston 1986, Drohan and Merkler 2009). Some plant collectors are not well trained in the identification of soil types, and thus either omit substrate information from herbarium labels or include possibly incorrect information (Johnston 1941b, Welsh 1978, Powell and Turner 1979). Second, taxonomic assignment is largely a subjective matter, and thus one botanist's species may be another's variety or genus (Kruckeberg and Rabinowicz 1985). Nevertheless, attempts have been made to estimate of the number of gypsophilous species in the Chihuahuan Desert Region from extensive literature surveys. Estimates range from at least 215 obligately gypsophilous species from 35 families (Moore 2005) to "several hundred" species representing approximately 150 genera and 50 families (Powell and Turner 1977). Several families and genera include multiple gypsum endemics, including Amaranthaceae, Portulacaceae, *Neriserynia* (Brassicaceae), *Tequilia* and *Nama* (Boraginaceae), *Frankenia* (Frankeniaceae), *Anulocaulis* and *Selinocarpus* (Nyctaginaceae), and *Gaillardia* and *Sartwellia* (Asteraceae; Johnston 1941, Powell and Turner 1979, Douglas and Manos 2007). Several of these genera – for example, *Neriserynia, Sartwellia*, and *Anulocaulis* – are almost exclusively composed of gypsum endemics (Moore and Jansen 2007).

Two hypotheses attempt to explain the evolution of edaphic endemics. The "refuge hypothesis" (Gankin and Major 1964) proposes that endemic species exploit substrates on which the "regionally dominant vegetation" cannot grow for reasons of soil nutrition and water availability and that these endemics are unable to compete with the dominant vegetation on typical soils. The "specialist model" (Meyer 1986) suggests that species become restricted to particular substrates because of physiological changes, and subsequently have reduced fitness on “normal" soils even in the absence of competition. That is, the “refuge hypothesis” suggests that endemics can survive on both typical and unusual substrates but are only found on the unusual substrates because they cannot compete with other vegetation on normal soils, and other vegetation cannot compete with endemics on unusual substrates. The specialist model suggests that edaphic endemics have evolved to specialize on unusual substrates to the detriment of their survival on typical soils. The geologic distribution of facultative gypsophiles, which successfully grow both on gypsosols and on non-gypsum substrates, is incompatible with the specialist hypothesis. They may fit the refuge hypothesis, becoming established on gypsum in areas where competition with other vegetation is high. Obligate gypsophiles, whether endemic to limited areas or with widespread distribution, might conform to either model (Palacio et al. 2007). Few studies have attempted to test these hypotheses (Meyer 1986, Palacio et al. 2007).

The evolution of gypsophily in plant groups is presently poorly understood, although there is growing interest in the topic. Two studies have previously examined the evolution of gypsum endemism across a family or genus using molecular systematics methods (*Tequilia*: Boraginaceae; Moore 2005, Moore and Jansen 2007; Nyctaginaceae: Douglas and Manos 2007). With 14 out of 52 species exhibiting a preference for gypsum ranging from facultative to obligate gyposphily (Tables 2.1 and 3.1), *Nama* is an excellent model system for exploring the evolution of gypsum endemism. Within *Nama*, there are four obligate gypsophiles, a single limestone endemic, and ten facultative gypsophiles (Table 3.1). Plants growing on gypsum-rich substrates are often morphologically distinct from close relatives that do not grow on gypsum (Powell and Turner 1977), possibly reflecting a long history of differentiation from related non-gypsophiles (Turner and Powell 1979, Moore and Jansen 2007). Within *Nama*, most of the obligate gypsophiles are indeed morphologically dissimilar from the other species in the genus. Whereas the non-gypsophilic species in the genus have a mat-forming, spreading, or decumbent habit, are generally not woody, and have ovate, elliptic, oblanceolate, or even rhombic leaves, the obligate gypsophiles are generally characterized by erect stature, a very robust and often woody habit, and generally linear leaves. The facultative gypsophiles in the genus are generally spreading or mat-forming, and usually bear elliptic, ovate or oval leaves.

The gypsophilous species in the Chihuahuan Desert Region include both widespread (*Nama stenophylla*) and narrowly distributed (*N. hitchcockii*) species. The well-supported chloroplast and ITS phylogenies reconstructed in Chapter 2 provided a backbone for exploration of various hypotheses addressing the origins of gypsophily within this diverse group. Two herbarium specimens in the TEX collections segregated by J. Bacon as an as-yet unpublished new species (*Nama* "*monclova*") were collected from gypsum outcrops, although we do not yet have sufficient data to discern whether the taxon is an obligate or facultative gypsophile; for the purposes of this analysis, it was considered a facultative gypsophile. Further discussion of how taxa sampled for this study were determined to be obligate or facultative gypsophiles is provided in the Methods section below. All gypsophiles in the genus are endemic to the Chihuahuan Desert and adjacent arid regions except for *N. stevensii*, which occurs in the Chihuahuan

Desert and ranges north to Kansas. Although the geographic range of *Nama* includes the Sonoran and Mojave deserts in the northern hemisphere and the Atacama and Monte deserts and lower elevations of the central Andean puna of South America, gypsum endemism has not been recorded for any species of *Nama* from those regions. Hitchcock (1933a; 1933b; 1939) produced an excellent monograph of the genus; fortunately the ca. 20 species subsequently named by other authors were likewise well described.

MATERIALS AND METHODS

Taxon sampling and outgroup selection

We obtained DNA from 46 of the 52 species of *Nama* that were recognized for this study, as well as from 4 undescribed putative new species: *N.* "*baconii*", *N.* "*monclova*", and *N.* "*whalenii*", which were segregated as possible new species by B. Turner and J. Bacon, and *N. "jimulco,"* which we identified (in prep.). Detailed information on taxon sampling and outgroup selection is available in Chapter 2 and summarized here. Of the six species for which we were unable to acquire DNA, four were known only from decades-old holotypes with sparse material (i.e., poor candidates for destructive sampling even if permission could be obtained) and could not be relocated in the field. Special effort was undertaken while in Mexico to locate the type locality for *N. rzedowskii,* an opposite-leaved plant from the vicinity of Rioverde, San Luis Potosi. While the holotype label (*Rzedowski 24777*) specifies that the collection was made from an alluvial plain with halophytic vegetation, Nesom (1990) asserted that *N. rzedowski* was endemic to the gypsum plains in the area. However, the search was unsuccessful, with only *N. berlandieri* observed in the area. A fifth species (*Nama segetalis*) was described after taxon sampling had been completed and much of the molecular work had been completed; we were unable to obtain genetic material. Attempts to isolate uncontaminated DNA from the sixth species, *N. rotundifolia*, failed and we were unable to sequence our chosen molecular markers for that taxon. Outgroup taxa were selected to represent genera that were closely related to *Nama* (*Eriodictyon* and *Wigandia*) and more distantly related yet still within the former Hydrophyllaceae (*Tricardia*, *Emmenanthe*, and *Phacelia*) as determined by Ferguson (1998). Voucher information for DNA samples was provided earlier in Table 2.4.

Tissue collection, DNA extraction, marker selection, amplification and sequencing

Materials and methods of tissue collection, DNA extraction, amplification, and sequencing are summarized here; detailed descriptions are available in Chapter 2. DNA was extracted from herbarium specimens with permission from LL, TEX, and NY and from silica-dried field-collected material following the protocol outlined in Doyle and Dickson (1987) or by using a QIAGEN DNEasy ® Plant Mini Kit (QIAGEN). Amplification of selected molecular markers (*mat*K, *ndh*F, and ITS) was accomplished by means of the polymerase chain reaction (see Chapter 2 for primer sequences and PCR reagent mixes, and Appendix A for thermocycler programs). PCR products were verified and quantified using agarose gel electrophoresis and a low mass ladder (Invitrogen) and subsequently cleaned using either Qiaquick columns (QIAGEN) or the standard ExoSAP protocol (Werle et al. 1994). Because of early signs suggesting the presence of multiple copies of ITS in sequenced PCR products, all ITS PCR products were cloned for all samples included in the study. Cloning reactions were performed using a TOPO TA Cloning Kit (Invitrogen) at one-third strength relative to the protocol specified in the kit manual, and a minimum of 10 colonies per reaction was sampled for PCR amplification.

At least 5 colonies per DNA accession were sequenced except in 6 cases (4 colonies were sequenced for *Nama jamaicensis*, *N. schaffneri*, and *N. havardii-203*; 3 colonies were sequenced for *N. californica* and *N. depressa;* 2 colonies were sequenced for *N. havardii-204*).

Cleaned PCR products (20-40 ng) were either prepared for automated sequencing on an MJ Research BaseStation by performing dye terminator cycle sequencing reactions, or were mixed with a single primer per reaction and sent to the Institute for Cellular and Molecular Biology (ICMB) DNA Sequencing Facility at the University of Texas at Austin for cycle sequencing and automated sequencing on ABI 3730 or ABI 3730XL DNA Analyzers.

After bidirectional sequencing, sequences for each accession were assembled into contigs and examined for ambiguities using Sequencher v4.5 (Gene Codes Corporation). Genetic sequences obtained for this study will be entered into Genbank prior to publication. Initial alignment of chloroplast sequences was accomplished with ClustalX (Thompson et al. 1997) while initial alignment of ITS sequences was performed with MUSCLE (Edgar 2004). Manual adjustment of alignments was performed using MacClade 4.08 (Maddison and Maddison 2000). The aligned ITS matrix was searched for short nucleotide sequences that are indicative of non-"pseudogene" ITS copies (Harpke and Peterson 2008), and clones lacking those indicators were pruned from the dataset. The location of ITS primer sites in highly-conserved flanking sequences is useful for easy amplification the marker; the downside of this utility is the ease with which contaminants may be amplified and sequenced. While initially all cloned ITS sequences were "blasted" against Genbank to preemptively avoid including contaminants in the data set, there remained the possibility of infrageneric contamination, which would not be apparent from the Genbank search results. For this reason, any sequences that seemed anomalously placed in preliminary ITS-based topologies (i.e., cases in which 4 of 5 clones of a given DNA accession formed a monophyletic group and the remaining clone was placed in a wholly different lineage) were scrutinized for potential contamination. This step resulted in the elimination of 9 clones from the ITS alignment (3 clones of *Nama depressa* and *N. californica*, 2 clones of *N. havardii-204*, and 1 clone of *N. densa-129*). For each data matrix, characters whose homology was uncertain (i.e., we had low confidence in the alignment) were excluded. These exclusions were limited to small regions of the highly-variable *trn*K introns at the 5' and 3' ends of *mat*K (17 bp) and ITS2 (31 bp).

The evolution of gypsophily within *Nama* was examined using the chloroplast data set (*mat*K and *ndh*F) and the ITS data set independently; data from the two genomes were not combined for these analyses.

Phylogenetic analysis

Detailed information regarding our phylogenetic methods is available in Chapter 2 and summarized here. MrModeltest v2.3 (Nylander 2004) was used to select the most appropriate model of nucleotide evolution for each dataset and partitions within each dataset. Maximum likelihood analyses were performed for each dataset using GARLI v.1.0 (Zwickl 2006) and RAxML v.7.2.8. (Stamatakis 2006, Stamatakis et al. 2008). Because GARLI did not recognize partitioned datasets, those analyses were run on unpartitioned data sets only. Using GARLI, 10 replicate searches were performed for the chloroplast dataset and 20 replicate searches were performed for the ITS dataset. For each analysis using RAxML, 10 replicates were performed for each dataset, utilizing a general time reversible model with gamma distribution of rate heterogeneity (specified as the GTRGAMMA algorithm within the software). Each RAxML replicate also included

100 bootstrap replicates using a fast approximation method. Bayesian analyses were conducted using MrBayes (Huelsenbeck and Ronquist 2001, Ronquist and Huelsenbeck 2003), with initial paired runs of 5 million generations examined using AWTY (Wilgenbusch et al. 2004) to assess convergence. If it was apparent that the two runs had not converged, analyses were continued in increments of 5 million generations. The Bayesian analysis of the ITS dataset reached convergence at around 2.5 million generations and was terminated early (after 4,253,400 generations). Analysis of the chloroplast dataset had not converged by 20 million generation and was rerun with the cold chain temperature set to 0.15 (default is 0.20) and subsequently convergence and stationarity were reached before 2 million generations.

Identification of gypsophiles

Species were classified as obligate or facultative gypsophiles based on field observations from multiple trips to West Texas and the Mexican states of Chihuahua, Coahuila, Nuevo Leon, San Luis Potosi, and Durango, as well as from soil descriptions and lists of associated plants on herbarium labels and by surveying various literature sources including floras of gypsum deposits and species descriptions. As noted in the introduction, soil descriptions on herbarium labels are sometimes unreliable or unclear given collectors' unfamiliarity with soil types. In the case of *Nama*, this could result in designating a truly obligate gypsophile as a facultative gypsophile if the collector did not recognize the presence of gypsum at the collecting locality and specifies a different substrate. Most of the collections examined were made by botanists with a particular interest in gypsophily and extensive collecting histories among gypsum deposits of the Chihuahuan Desert Region, such as Ivan Johnston, James Henrickson, and George and James Hinton; their assessments of whether or not plants were found growing on gypsum were considered to be credible and reliable. Unless there is reason to suspect inaccuracy on an herbarium label, in a published flora, or a species description, it is reasonable to assume that the information therein is accurate (Wilson and Pitts 2010). This standard has been employed in evaluating the evolution of gypsophily in Nyctaginaceae (Douglas and Manos 2007).

Ancestral state reconstruction

Ancestral edaphic preferences were reconstructed using MacClade 4.08 (Maddison and Maddison 2000). States were coded as 0 (non-gypsophiles), 1 (facultative gypsophiles), 2 (obligate gypsophiles) or 3 (limestone endemics) and traced on the best-scoring ML tree found by RaxML for the chloroplast and ITS data sets. The ITS ML tree was pruned to a single clone per species for all species that had formed monophyletic groups in the phylogeny. For taxa that did not form monophyletic groups in the ITS phylogeny we retained multiple samples covering the topological range they exhibited. Characters were unordered (allowing transition from any one type of edaphic preference to any other type in one step) and transitions were assessed under both ACCTRAN (accelerated transition, which places any state changes as early in each tree as possible) and DELTRAN (delayed transition, which locates state changes as late as possible in each tree).

Hypothesis testing

Obligate and facultative gypsophily were mapped onto the best-scoring chloroplast and ITS trees as found by maximum likelihood and Bayesian searches. Hypotheses were evaluated using a suite of tests available in the Consel software package (Shimodaira and Hasegawa 2001): the Approximately Unbiased test (AU test; Shimodaira 2002), the Shimodaira-Hasegawa test (SH test; Shimodaira and Hasegawa

1999) and the weighted Shimodaira-Hasegawa test (WSH test; Shimodaira and Hasegawa 1999). Hypotheses were also tested using the SOWH test (Swofford et al. 1996; Goldman et al. 2000) and by evaluating the Bayesian posterior probabilities for each hypothesis. The significance level (a) was set to 0.05 for all hypothesis tests.

The hypotheses that were examined for this study fell into three broad categories: monophyly of all gypsophiles, monophyly of obligate gypsophiles, and monophyly of facultative gypsophiles. A list of all hypotheses that were tested is provided in Table 3.2, with constraint trees illustrated in Figure 3.2. Several hypotheses were tested twice, because the edaphic preference (if any) of *Nama "jimulco"* was unknown. For each hypothesis that could possibly have included the new species we created one constraint tree that included *N. "jimulco"* and one that excluded it. The voucher for *N. "jimulco"* (*Villarreal and Carranza 4420* (LL, TEX)) was initially determined to be *N. johnstonii*, a limestone endemic that closely resembles the other members of the *Nama stenophylla* clade. The herbarium label for this voucher does not indicate on what kind of substrate this plant was collected. Notably, there are several morphological differences between this specimen and the species description, type, and other specimens of *N. johnstonii*. Most remarkably, the new species has leaves that are intermediate in width between the linear leaves of most of the clade and the ovate leaves of *N. havardii.* Preliminary phylogenetic analyses indicated that this specimen did not have a sister relationship with either *N. johnstonii* or *N. havardii*. Given its morphological similarity to these two species, and its dissimilarity to the obligate gypsophiles *N. canescens, N. carnosa,* and *N. stenophylla*, it seems unlikely that this new species is an obligate gypsophile.

PAUP* v.4b10 was used to obtain the site-wise log likelihoods for each tree under consideration (i.e., the ML tree found by GARLI and the constraint trees representing each hypothesis), using the model parameters as output by GARLI, for both the chloroplast and ITS datasets. The software package CONSEL carried out nonparametric bootstrapping on those site-wise log likelihoods and subsequently performed the KH (Kishino and Hasegawa 1989), SH, WSH, and AU tests. The KH test is only appropriately employed when all trees under consideration are specified *a priori* (Swofford et al. 1996, Goldman et al. 2000); because the best-scoring ML trees do not fit this criterion, the results of that test were not considered. The SH test was devised to minimize the selection bias observed in the KH test such that trees specified *a posteriori*, such as ML trees, could be included in the test, but it can be increasingly conservative as the number of trees under consideration increases (Shimodaira 2002). The AU test addresses the selection bias inherent in the KH test and is less conservative than the SH test (Shimodaira 2002).

The SOWH test utilizes parametric bootstrapping to generate a distribution of dscores (the difference in log likelihood scores of trees obtained through paired unconstrained and constrained ML searches) to which the observed difference between log likelihood scores of unconstrained and constrained ML searches using the chloroplast or ITS datasets is compared (Swofford et al. 1996, Goldman et al. 2000). Using GARLI, we found the best-scoring ML tree for each constraint (i.e., each hypothesis) using both the chloroplast and the ITS data sets. SeqGen (Rambaut and Grassly 1997) was used to simulate 100 replicate datasets based on the best-scoring ML constraint tree and the model parameters for that tree as reported by GARLI. Paired maximum likelihood searches were performed on each replicated data set to find the best-scoring unconstrained ML tree and the best-scoring ML tree under the constraint. The differences in log likelihood scores between the resulting trees formed the distribution against which we could compare the observed difference between the best-scoring ML tree obtained from analysis of the chloroplast or ITS data and the best-scoring ML tree under the constraint. Given a significance level (a) of 0.05, the SOWH test rejects a given hypothesis if the observed difference in log likelihood scores between unconstrained and constrained trees is larger than 95% of the d-scores in the distribution.

The Bayesian posterior probability of each hypothesis was obtained by loading post-stationarity trees from the chloroplast (20000 trees) or ITS (5070 trees) generated by MrBayes into PAUP* and filtering each set of trees with the constraint trees representing each hypothesis. The set of trees retained by the filter includes all post-stationarity trees that are congruent with the constraint tree. This proportion of trees (trees retained by the filter / all post-stationary trees) is the posterior probability of the constraint tree.

RESULTS

Major lineages and the distribution of gypsophiles across *Nama*

Analyses of the chloroplast and ITS data sets yielded identical sets of seven major lineages: the *Nama densa* clade, the *Nama stenophylla* clade, the *Nama jamaicensis* clade, the *Nama serpylloides clade,* the *Nama hispida* clade, the *Nama dichotoma* clade, and the *Nama hirsuta* clade. One species, *N. stenocarpa*, was not consistently associated with any single major lineage. Analyses of the chloroplast data set placed *N. stenocarpa* sister to the *Nama serpylloides* lineage, while it was sister to the *Nama jamaicensis* clade in the ITS phylogeny. Relationships among the major clades varied based on data set (Figure 3.3). Facultative and obligate gypsophily were mapped onto the best-scoring maximum likelihood trees for the chloroplast and ITS data sets (Figures 3.4 – 3.8). Gypsum endemics occurred in four of the seven major lineages of *Nama*: the *Nama stenophylla* clade, the *Nama jamaicensis* clade, the *Nama hispida* clade, and the *Nama serpylloides* clade (Figure 3.3). These four lineages collectively encompassed 33 species, of which 13 (including one undescribed putative new species, *N. "monclova"*) positively exhibit some degree of gypsum tolerance or preference. With the exception of one limestone endemic (*N. johnstonii*), all of the species of the *Nama stenophylla* clade were either facultative (5 species, if *N. "jimulco"* is included) or obligate (3 species) gypsophiles. The *Nama hispida*, *Nama serpylloides,* and *Nama jamaicensis* lineages each included a mix of gypsophiles and non-gypsophiles. All analyses of the choloroplast data set recovered a monophyletic group comprising these four major lineages ((bs=100%; PP=1.00; Figure 3.3A). *Nama stenocarpa* is a single species that was sister to the *Nama serpylloides* clade in the chloroplast phylogeny but sister to the *Nama jamaicensis* clade in the ITS phylogeny. These four lineages formed a paraphyletic group in analyses of the ITS data set (Figure 3.3B, C). The most recent common ancestor of the four lineages also gave rise to the *Nama dichotoma* clade as a descendant in the best-scoring ML tree found by GARLI (albeit with <50% bootstrap support), and gave rise to both the *Nama dichotoma* and *Nama hirsuta* clades in the best-scoring tree recovered by RAxML (bp < 50% but pp=1.0). Mapping gypsophily onto the chloroplast and ITS phylogenies revealed that none of the groups of interest (facultative gypsophiles, obligate gypsophiles, or all gypsophiles) formed monophyletic groups in either the chloroplast or the ITS phylogenies (Figures 3.4 – 3.8).

Obligate gypsophiles were nearly exclusive to the *Nama stenophylla* clade (Table 3.1); the only obligate gypsophile found elsewhere in the tree was *N. stevensii*, which all analyses placed distantly in the *Nama hispida* clade. Thus both the ITS and chloroplast phylogenies suggested at least two independent origins of obligate gypsophily within *Nama*. The facultative gypsophiles were likewise concentrated in the *Nama stenophylla* clade, which included 5 of the 10 facultative gypsophiles in *Nama*. There were 3 facultative gypsophiles in the *Nama hispida* clade, and one each in the *Nama serpylloides* clade (*N. serpylloides*) and the *Nama jamaicensis* clade (*N. palmeri*). In all four major lineages, facultative gypsophiles were scattered among obligate gypsophiles or non-gypsophiles, and there was no clear evolutionary pattern for the distribution of facultative gypsophiles across either the chloroplast or the ITS phylogeny (Figures 3.4 to 3.8).

Interspecies relationships within the *Nama stenophylla* lineage were incongruent between the chloroplast and ITS phylogenies (Figure 3.4 and 3.5). Analyses of both data sets recovered a sister relationship of *Nama canescens* and *N. hitchcockii* (cp BP = 100, PP=1.00; ITS BP = 81, PP=1.00) and suggested a close (but statistically unsupported) relationship between *N. constancei, N. "jimulco,"* and *N. johnstonii*. The positions of *N. carnosa, N. havardii, N. flavescens,* and *N. stenophylla* were incongruent between the two topologies. Neither the ITS nor the chloroplast phylogeny recovered monophyletic groups comprising either facultative or obligate gypsophiles in this major clade, suggesting multiple changes from facultative to obligate gypsophily over the evolutionary history of the lineage.

Tracing the origin(s) of gypsophily within the *Nama hispida* clade lineage appeared to be complicated, given the low statistical support for nodes in the clade and the apparent polyphyly of *N. hispida* and *N. turneri*, two of the three facultative gypsophiles in this lineage. Branches within this clade were generally poorly to moderately supported by nonparametric bootstrapping in both the chloroplast and ITS phylogenies. Within the chloroplast phylogeny, 10 of 14 branches in the *Nama hispida* clade had bootstrap support values of 85% or below (Figure 3.4). Statistical support was even for the ITS dataset, where all interspecies relationships within the clade had less than 70% bootstrap support (Figure 3.6). Furthermore, we sampled several accessions of *N. hispida*, and those sequences did not form a monophyletic group in either the chloroplast or the ITS phylogenies. Within the chloroplast phylogeny, two accessions of *N. hispida* were more closely related to *N. xylopoda* – a nongypsophile - than to other *N.*

hispida samples, although the branch uniting these three samples received less than 50% bootstrap support (Figure 3.4). Cloned ITS sequences obtained from several *N. hispida* accessions were intermixed with clones obtained from *N. turneri* (Figure 3.6). However, even given these complications, the distribution of gypsophiles in the *Nama hispida* clade observed in both the chloroplast and ITS phylogenies could be explained by inferring a single gain of gypsophily followed by two losses. Alternatively, if we disallow the possibility that a non-gypsophile could evolve from a gypsophilic ancestor, the observed distribution could be explained by the inference of four independent origins of gypsophily.

Hypothesis testing

The results of all hypothesis tests are available in Tables 3.3 and 3.4. The chloroplast and ITS data sets were used to evaluate each hypothesis independently (described in Table 3.2). Every statistical tool rejected two hypotheses: that all gypsophiles collectively formed a monophyletic group (when *Nama "jimulco"* was considered a facultative gypsophile) and all facultative gypsophiles (both including and excluding *N. "jimulco"* as a gypsophile) formed a monophyletic group. SOWH tests and evaluation of Bayesian posterior probabilities of each hypothetical topology performed on both the chloroplast and ITS data sets resulted in the rejection of all hypotheses.

When evaluating the chloroplast data set, the only statistical tool that did not reject all hypotheses was the SH test, which (as noted in the methods above) has been shown to be conservative: it tends to include a large number of trees in its confidence set as the number of tested topologies increases (Shimodaira 2002). Results of the SH tests of the chloroplast data set were unable to reject the hypotheses of single origins of facultative or obligate gypsophile within the *Nama stenophylla* clade ($p=0.169$ for monophyly of obligate gypsophiles and p=0.279 or p=0.247 for monophyly of facultative gypsophiles, depending on whether or not *N. "jimulco"* was included as a facultative gypsophile). The results of the SH test also did not reject hypotheses of a monophyletic group of gypsophiles (p=0.557) or facultative gypsophiles (p=0.429) in the *Nama hispida* clade.

Hypothesis testing utilizing the ITS data set yielded a similar set of results (Table 3.4). Four of the hypotheses were rejected by all of the statistical tests: monophyly of all gypsophiles; monophyly of all facultative gypsophiles; monophyly of the facultative gypsophiles within the *Nama stenophyllum* clade when *N. "jimulco"* was included as a gypsophile; and monophyly of all gypsophiles within the *Nama hispida* clade. When *N. "jimulco"* was excluded from the facultative gypsophiles, the AU test and the SH test were unable to reject the hypothesis of monophyly of facultative gypsophiles within the *Nama stenophylla* clade (AU p=0.083; SH p=0.397). These two tests also did not reject the hypothetical monophyly of the obligate gypsophiles within the *Nama stenophylla* clade (AU p=0.17; SH p=0.249). The remaining three hypotheses – monophyly of all gypsophiles (excluding *N. "jimulco"*), monophyly of all obligate gypsophiles, and monophyly of the facultative gypsophiles within the *N. hispida* clade – were rejected by all statistical tests except the SH test (p=0.155, p=0.513, p=0.159 respectively).

Ancestral state reconstruction

MacClade found 32 most parsimonious reconstructions (MPRs) of 14 steps to explain the distribution of facultative and obligate gypsophily and limestone endemism across the chloroplast phylogeny (Figure 3.9). Given the ITS phylogeny, MacClade found 42 MPRs of 16 steps to explain how edaphic endemism was distributed across the tree (Figure 3.10). The ACCTRAN reconstructions of both the chloroplast and ITS phylogenies determined the ancestor of the *Nama stenophylla* lineage to be equivocal between facultative and obligate gypsophily; in both phylogenies, an obligate gypsophile (*N. carnosa* in the chloroplast tree and *N. stenophylla* in the ITS tree) was sister to the remaining species of the lineage. In contrast, the DELTRAN reconstructions of both phylogenies reconstructed a non-gypsophilic ancestor for the *Nama stenophylla* lineage.

Given the chloroplast phylogeny, the DELTRAN reconstruction of ancestral states reconstructed the ancestor of *Nama canescens* (an obligate gypsophile) and *N. hitchcockii* (a facultative gypsophile) as equivocal, whereas the ACCTRAN resolved the ancestor to be a facultative gypsophile. The two accessions of *N. palmeri* (the sole gypsophile of the *Nama jamaicensis* lineage) that we sampled did not form a monophyletic group. Instead, they formed a grade between *Nama jamaicensis* and the remaining species of the *Nama jamaicensis* lineage. For this reason, the ACCTRAN and DELTRAN reconstructions differed in reconstruction of the ancestral states of this lineage. The DELTRAN reconstruction inferred two origins of facultative gypsophily – one origin for each sample of *N. palmeri.* In contrast, the ACCTRAN reconstruction specified that the most recent common ancestor (MRCA) of *N. palmeri* and a clade of 5 species that was more derived than *N. palmeri* in the grade was a facultative gypsophile; subsequently there was one reversal to non-gypsophily for the MRCA of *N. spatulata, N. schaffneri, N. bartlettii, N. hintoniora,* and *N. biflora.* Within the *Nama serpylloides* lineage, there was just a single gypsophile (*N. serpylloides*), however, the three accessions that we sampled were polyphyletic. Thus the DELTRAN reconstruction inferred three independent origins of facultative gypsophily (one origin for each accession), while the ACCTRAN reconstruction inferred two origins: one origin for *N. serpylloides* var. *velutina*, and one origin for the MRCA of *N. serpylloides* var. *serpylloides* and *N. cuatrocienegensis*, followed by a reversal to non-gypsophily for *N.*

cuatrocienegensis. The two methods of reconstruction also differed on the assessment of the origins of gypsophily in the *Nama hispida* lineage. As was the case in the *N. jamaicensis* and *N. serpylloides* lineages, the multiple accessions of *N. hispida* and *N. turneri* – two of the four gypsophiles in the *Nama hispida* clade – did not form monophyletic groups, thus potentially inflating the number of state changes over this portion of the phylogeny. The DELTRAN and ACCTRAN reconstructions both inferred two origins of facultative gypsophily: one origin in the ancestor of *N. hispida-107* and *N. hispida-195*, and the second origin in the ancestor of *N. coulteri, N turneri, N. monclova, N. stevensii,* and the remaining two accessions of *N. hispida.* Subsequently there was one change to non-gypsophily for *N. coulteri* and one change to obligate gypsophily for *N. stevensii.*

Although the ITS phylogeny was in several respects incongruent to the chloroplast phylogeny, the ACCTRAN and DELTRAN reconstructions were generally in agreement for equivalent branches in the chloroplast phylogeny. For example, results for the ancestor of the *Nama stenophylla* lineage were identical to the chloroplast results. Results for the *Nama jamaicensis* were likewise congruent, with the DELTRAN reconstruction inferring independent origins of facultative gypsophily for each accession of *N. palmeri* and the ACCTRAN reconstruction identifying the MRCA of *N. palmeri* and all species in the clade derived from the basal grade of *N. palmeri* as a facultative gypsophile, with a subsequent reversal to non-gypsophily in the ancestor of the derived clade (Figure 3.10). Regarding the origin of gypsophily in the *Nama hispida* clade, the ACCTRAN reconstruction was identical to the reconstructions for the chloroplast phylogeny. In contrast, the DELTRAN reconstruction identified the ancestor of a six-species clade (*N. hispida, N. coulteri, N. turneri, N. "monclova," N. stevensii, N.*

xylopoda) as a facultative gypsophile, with subsequent changes to non-gypsophily for *N. coulteri* and *N. xylopoda.*

DISCUSSION

Evolutionary relationships and the origins of gypsophily in *Nama*

The presence of multiple gypsum-adapted taxa within a genus could arise by three means: colonization of gypsum by a single species which subsequently diversifies, giving rise to multiple gypsophilic descendents; via independent colonization events by multiple species; or by a combination of the two processes. The third scenario appears to have occurred within *Nama*. One lineage, the *Nama stenophylla* clade, is entirely composed of edaphic endemics, comprising 3 obligate gypsophiles, 5 facultative gypsophiles (putatively including *N. "jimulco"*), and a single limestone endemic (*N. johnstonii*). The most recent common ancestor (MRCA) of these species most likely was either a facultative or obligate gypsophile. In contrast, two of the major lineages (the *Nama jamaicensis* and *Nama serpylloides* clades) each have just a single facultative gypsophile, with the majority of species in those clades not exhibiting any known edaphic endemism. The *Nama hispida* lineage is intermediate between these extremes, comprising 6 non-gypsophiles, 3 facultative gypsophiles, and a single obligate gypsophile.

Hypotheses regarding the possible monophyly of all gypsophiles, obligate gypsophiles, or facultative gypsophiles were rejected by all statistical tests performed on the chloroplast and ITS datasets, with two exceptions. In tests of the ITS data set, the SH test did not reject hypothetical monophyly of all gypsophiles when *Nama "jimulco"* was excluded ($p=0.155$) or the monophyly of all obligate gypsophiles ($p=0.514$). However, these hypotheses were rejected in analyses of the chloroplast data set, which has generally equivalent species relationships with respect to placement within major lineages. The inability of the SH test to reject these two hypotheses is likely attributable to a combination of weak branch support values in the ITS phylogeny and the known conservative bias of the SH test, leading to Type II error (failing to reject a hypothesis when it is false).

If the chloroplast phylogeny (Figure 3.4) approximates the true "species tree" for *Nama*, then we could infer a single origin of gypsophily in the common ancestor of the four major clades that include gypsophiles. However, because gypsophiles are scattered throughout the *Nama hispida*, *Nama jamaicensis*, and *Nama serpylloides* clades, we would also have to infer more than 10 "losses" of gypsophily or reversals to non-gypsum habitats. If we assume that the paraphyly and polyphyly observed for several gypsophiles in the chloroplast phylogeny are the result of stochastic error and furthermore assume that those species truly are monophyletic, then a more parsimonious explanation for the observed distribution of gypsophiles across the chloroplast phylogeny would infer 4 or 5 independent gains of gypsum endemism (a single gain in the ancestor of the *Nama stenophylla* clade; a single origin in each of the *Nama hispida* and *Nama jamaicensis* clades; and 1 or 2 gains in the *Nama serpylloides* clade) followed by 2 losses in the *Nama hispida* clade. Despite the incongruent relationships among the major lineages between the chloroplast and ITS data sets (Figure 3.3), mapping gypsophily on to the ITS phylogeny (Figures 3.5 to 3.8) likewise suggests 4 or 5 gains of gypsophily followed by two losses, again in the *Nama hispida* clade. Ancestral state reconstruction analyses inferred a total of 14 changes in edaphic preference for the chloroplast phylogeny and 16 changes for the ITS phylogeny. These higher estimates are directly attributable to the fact that *N. hispida, N. palmeri,* and *N. serpylloides* are not recovered as monophyletic in either the chloroplast or the ITS phylogenies, increasing the number of state changes required to explain the observed distributions.

Interspecies relationships within the *Nama stenophylla* clade

Relationships among the species of the *Nama stenophylla* clade are largely incongruent between the chloroplast and the ITS phylogenies (Figures 3.4 and 3.5). The topologies are in agreement that *N. canescens*, an obligate gypsophile that is widespread along the western edge of Nuevo Leon (Figure 3.11A), is sister to *N. hitchcockii*, which is a narrowly distributed facultative gypsophile in the vicinity of Galeana, Nuevo Leon (Figure 3.11B), where the two species are sympatric. These two species are easily distinguished by leaf length (up to 6 cm in *N. hitchcockii* and less than 3 cm in *N. canescens*), corolla length (8 mm or longer in *N. hitchcockii* vs. 8 mm or shorter in *N. canescens*) and flower color (*N. hitchcockii* has yellow or cream-colored corollas, while *N. canescens* is characterized by pink or purple corollas). The topologies reconstructed from the two datasets also agree on a close relationship between *N. johnstonii* and *N. constancei*. In the chloroplast phylogeny, *N. johnstonii* is sister to *N. constancei*, and the two together are sister to *N. "jimulco"* (Figure 3.4). Support for the branch uniting *N. constancei* and *N. johnstonii* is moderate (BP=80%; PP=0.82), while the branch uniting all three species is unsupported. Analysis of the ITS data set likewise reconstructs a close relationship of these three species, however, *N. flavescens* appears to be closely related to them rather than to *N. stenophylla* as in the chloroplast phylogeny (Figures 3.4 and 3.5). Whereas the clones of most species in the *Nama stenophylla* lineage form monophyletic groups, the clones of *N. johnstonii* form two distinct groups, appearing both in a derived position intermixed with *N. flavescens* clones as well as appearing in a grade between *N.*

"jimulco" and *N. constancei.* The geographic distributions of *N. flavescens* and *N. johnstonii* overlap in the vicinity of Parras, Coahuila (Figure 3.11C and D), and both species are frequently collected from limestone or shale deposits; whereas *N. johnstonii* appears to be endemic to such deposits, *N. flavescens* also grows on gypsum in Coahuila and Zacatecas and was considered a facultative gypsophile in this study. The incongruent placement of *N. flavescens* could be attributable to introgression, although our sample of *N. flavescens* (*M.C. Johnston et al. 11543A*) was collected near Cedral, Zacatecas, while the sample of *N. johnstonii* (*Hinton et al. 23340*) was collected approximately 250 km away in Parras, Coahuila.

In the chloroplast phylogeny, *Nama flavescens* is strongly supported as sister to *N. stenophylla* (BP=100%; PP=1.00), an arrangement that is supported by morphology: the former species has in the past been considered a variety of the latter due to their similarity in leaf length, corolla size, and corolla color but was most recently elevated to specific status by Hitchcock (1939). Hitchcock (1939) proposed a close relationship between *N. flavescens*, *N. stenophylla*, *N. johnstonii*, and *N. carnosa*, suggesting a common origin for the four species. This arrangement is not supported by either the chloroplast or the ITS phylogenies. While *N. carnosa* has only been collected from the United States (NM and TX) and northern Chihuahua (Figure 3.11E), the geographic distributions of *N. flavescens* and *N. johnstonii* are encompassed by the widespread range of *N. stenophylla* (Figure 3.11C-E). More generally, the recovery of monophyletic groups in the ITS phylogeny for the clones of each species in the *Nama stenophylla* lineage (with the exceptions of *N. flavescens* and *N. johnstonii*) suggests that most species within the clade have been genetically isolated for a long period of time.

Evolution of edaphic endemism in the *Nama stenophylla* lineage

Powell and Turner (1979) remarked that some gypsum endemics of the Chihuahuan Desert Region "might even be described as bizarre by comparison with related taxa." This is certainly the case for the species of the *Nama stenophylla* clade, which are strikingly different morphologically from the rest of the genus. The species of the *Nama stenophylla* clade are generally robust (often woody at the base, but not universally so), relatively tall plants (up to 60 cm) with succulent, terete, linear leaves; the two exceptions are *Nama havardii* and *N. "jimulco,"* which are herbaceous plants bearing narrowly elliptic or oblanceolate leaves. In contrast, nearly all of the remaining 44 species in the genus – including other Chihuahuan Desert natives – range from low-growing, mat-forming subshrubs or spreading herbs to ascending or erect herbaceous plants bearing elliptic, obovate, oblanceolate, cordate, or deltoid leaves.

None of the molecular phylogenetic analyses recovered monophyletic groups of facultative or obligate gypsophiles within the *Nama stenophylla* lineage for either the chloroplast or the ITS phylogenies. The hypothesis that the obligate gypsophiles – *N. canescens, N. carnosa, and N. stenophylla* – form a monophyletic group was rejected by the SOWH test for both the chloroplast and ITS data sets ($p<0.01$ for both, Tables 3.3 and 3.4). This hypothesis was not rejected by the SH test (chloroplast $p=0.169$; ITS $p=0.249$); the AU test rejected the hypothesis for the chloroplast data set ($p<0.01$) but was unable to reject it for the ITS data set ($p=0.17$). None of the post-stationarity trees from the Bayesian analyses of either data set contained a monophyletic group of these three species. Similarly, the more powerful statistical tests rejected the hypothetical monophyly of the facultative gysophiles of the *Nama stenophylla* lineage for both the chloroplast and ITS data sets. This is unsurprising, because *N. johnstonii* was recovered as nested well within a group of facultative and obligate gypsophiles in all ML trees;

monophyly of facultative gypsophiles would require the exclusion of this species. However, the SH test could not reject this hypothesis for the chloroplast data set regardless of whether or not *N. "jimulco"* was included as a gypsophile (p=0.279 and p=0.247, respectively), and neither the AU nor the SH test rejected it for the ITS data set when *N. "jimulco"* was excluded AU p=0.083; SH p=0.397). Given the recognized conservative bias of the SH test (Goldman et al. 2000) and the increased power of the parametric SOWH test compared to the nonparametric SH and AU tests, and considering the strong support for several branches in the *N. stenophylla* lineage in both the chloroplast and ITS phylogenies, it seems probable that the facultative and obligate gypsophiles here do not form monophyletic groups. Instead, it appears from the distribution of obligate gypsophiles in both phylogenies that obligate gypsophily has arisen several times from facultatively gypsophilic ancestors.

Ancestral state reconstruction for the *Nama stenophylla* lineage as recovered by analyses of the ITS dataset indicates that the most parsimonious explanation for the distribution of facultative gypsophily, obligate gypsophily, and calciphily in this group invokes 9 changes, which is reduced to 7 changes if the clones of *Nama johnstonii* are constrained to form a monophyletic group (Figure 3.10). Five state changes are invoked to explain the distribution of gypsophily in the chloroplast phylogeny.

In both the chloroplast and ITS phylogenies, a single obligate gypsophile is recovered as sister to the remaining taxa in the *Nama stenophylla* lineage. However, the identity of that obligate gypsophile differs between data sets. The chloroplast phylogeny recovers *N. carnosa* as sister to the rest of the lineage (BP for the branch uniting the remaining species = 99%, PP=10), whereas the ITS phylogeny suggests that *N. stenophylla* is sister the rest of the clade (BP <50%, PP<0.5). In both cases, the ancestor of the sister clade was reconstructed as either equivocal (facultative or obligate gypsophile) or a facultative gypsophile. If *N. carnosa* is sister to the rest of the *N. stenophylla* clade in the true species tree, it would be plausible to infer that the distribution of the most recent common ancestor of the entire lineage might have been limited to the eastern edge of the Chihuahuan Desert Region (e.g. Figure 3.9E). The area of desert in eastern Coahuila and western Nuevo Leon marks the highest species diversity of gypsophiles in *Nama* and conceivably been the region where the *Nama stenophylla* lineage originally diversified. Alternatively, if the ancestor of the *Nama stenophylla* clade approximated the present-day distribution of *N. stenophylla* (Figure 3.11F), it would have been widespread across the central region of the Chihuahuan Desert, extending from Chihuahua to the western edge of Nuevo Leon. This could have resulted in relatively early genetic isolation of populations on solitary gypsum deposits, ultimately resulting in multiple speciation events.

The species of the *Nama stenophylla* lineage offer several clues that the group may be extremely old. First, eight of the 10 species have significantly diverged morphologically from the rest of the genus. Such extreme divergence would require a long time to occur. Secondly, species of this lineage have colonized gypsum deposits throughout the Chihuahuan Desert (Figure 3.11A – I). Since these gypsum outcrops are scattered throughout the desert like islands, often at great distance from each other, long-distance dispersal is required for *Nama* to move from one outcrop to another. However, the seeds and fruits of *Nama* are not particularly adapted for long-distance dispersal; they lack wings, hooks, or fleshy parts, but may be transported by water or wind. In either case, dispersal by such a manner for successful colonization of new gypsum habitats might be expected to require a long period of time. Finally, the diversification of the lineage into at least 10 species (and more are likely to be discovered in the future, as many gypsum deposits in central Coahuila are difficult to reach and remain unexplored;

Moore 2005) that are well-differentiated morphologically and genetically suggests that the *Nama stenophylla* clade originated quite long ago. While analyses to estimate node ages in *Nama* were not conducted for this study, Moore and Jansen (2007) estimated that *Tiquilia* subg. *Eddya* (a lineage entirely composed of gypsophiles in the southwestern US through central Mexico) arose 33-24 Ma (million years ago) during a period of global drying and diversified into its major lineages by 23-14 Ma. Further analysis is required to ascertain whether the *Nama stenophylla* lineage is similarly ancient.

Interspecies relationships and the origin of gypsophily in the *Nama jamaicensis* clade

The *Nama jamaicensis* clade includes a single facultative gypsophile, *N. palmeri*. The species is widely distributed across the southeastern Chihuahuan Desert (Figure 3.11J) but has only been collected from gypsum outcrops from 3 gypsum outcrops west of Aramberri, southeast of Galeana (both in Nuevo Leon) and north of Paraiso (in San Luis Potosi). Rather than gypsum, most collection records indicate the presence of limestone, caliche, clay, or unspecified rocky substrates (Appendix C). Clearly, this is a species that possesses the ability to grow on gypsum but does not often do so. The position of *N. palmeri* is incongruent between the chloroplast and ITS phylogenies. Analyses of the chloroplast data indicate that the two accessions of *N. palmeri* that were sampled do not form a monophyletic group, but occur in a grade between *N. jamaicensis* and a clade containing *N. schaffneri, N. spathulata, N. hintoniora, N. biflorum,* and *N. bartlettii* (Figure 3.4). Within the ITS phylogeny, the clones of each species in the *Nama jamaicensis* lineage form monophyletic groups except for those of *N. palmeri* and *N. hintoniora*. The clones of *N. hintoniora* form two monophyletic groups, both of which are in a derived position and subtended by grades of *N. palmeri* clones. An additional clade of *N. palmeri* clones is sister to the clade of *N. schaffneri* clones. The two types of

N. palmeri clones – those associated with *N. hintoniora* and those associated with *N. schaffneri* – are not segretated by accession (Figure 3.7). Rather, clones from both accessions appear in both groups, indicating polymorphism shared by both specimens that we sampled. *Nama hintoniora* and *N. palmeri* are sympatric throughout the former's narrow geographic distribution, which forms a triangle delineated by the cities of Saltillo, Monterrey, and Ciudad Victoria in Nuevo Leon (Figure 3.11K). The two species are distinguished by vestiture (*N. hintoniora* is characterized by hirsute vestiture throughout, while *N. palmeri* is sericeous) and the presence of filiform pedicels in *N. hintoniora* and stout, thick pedicels in *N. palmeri*. Given the genetic mixing between these two species that is evident in the ITS phylogeny (but not indicated in the chloroplast phylogeny), incomplete lineage sorting or introgression seem plausible explanations for the observed pattern.

Nama palmeri appears to be an opportunistic resident of gypsum outcrops in the Chihuahuan Desert. What factors could explain why this species is the only member of the *Nama jamaicensis* clade that has colonized gypsum? The closest relatives of *N. palmeri* occur in the same geographic area just outside the eastern edge of the Chihuahuan Desert, however, they are often found in mixed woods, by stream banks, or in other mesic environments (e.g., the holotype of *N. spatulata*, *Brandegee 2584,* was collected from "moist soil;" *N. biflora* is frequently collected from riparian zones). These species possibly have higher moisture requirements than *N. palmeri* and thus could not survive in the arid locations where gypsum is prevalent. Alternatively, they may possess genetic adaptation to growing on gypsum but have not dispersed to areas where gypsum is common. It is unlikely that *N. palmeri* has existed on gypsum deposits for any great length of time: it has not diverged a great deal morphologically from its closest relatives and in fact is not frequently collected from gypsum deposits, seeming to prefer limestone outcrops instead.

Interspecies relationships and the origin of gypsophily in the *Nama serpylloides* clade

Four species of the *Nama serpylloides* lineage were sampled for this study: *N. serpylloides, N. cuatrocienegensis, N. torynophylla,* and *N. parvifolia.* A fifth species, *N. rzedowskii,* is known only from the holotype (*Rzedowski 2477*), collected in the vicinity of Rioverde in San Luis Potosi. The opposite leaves of *N. rzedowskii* almost certainly place it among the species of the *Nama serpylloides* clade, as that phyllotaxy is characteristic of *N. serpylloides, N. cuatrocienegensis,* and *N. parvifolia.* Opposite leaves are not found in any of the other major lineages of *Nama.* Unfortunately, we were unable to find *N. rzedowskii* in the field and thus were unable to ascertain whether the species is a halophyte, as suggested by its herbarium label ("alluvial plains with halophytic grasses and *Prosopis"*) or a gypsophile, as asserted by Nesom (1990). It may be that the species is able to grow in both habitats; its presumed close relative, *N. serpylloides,* has been collected from both gypsum flats and saline seeps and was referred to as a "halophytic gypsophile" by Johnston (1941a). Further reconnaissance to collect *N. rzedowskii* is needed to clear up the uncertainty regarding its substrate preference(s).

The chloroplast and ITS phylogenies are largely congruent with respect to the *Nama serpylloides* lineage. Both datasets recover a close relationship between *N. torynophylla* and *N. parvifolia,* and between *N. serpylloides* var. *serpylloides* and *N. cuatrocienegensis.* However, the placement of *N. serpylloides* var. *velutina* differs between the two topologies. Analyses of the chloroplast data set recover *N. serpylloides* var. *velutina* sister to *N. torynophylla* (Figure 3.4) albeit with low statistical support (BP=74%, PP<0.5), whereas analyses of the ITS data set place all clones of var. *velutina* in an unsupported derived clade intermixed with var. *serpylloides* clones and subtended by a grade of *N. cuatrocienegensis* clones. The branch uniting all 3 taxa has weak bootstrap support (BP=77%) but strong Bayesian support (PP=1.0), and branches within this group are weakly supported at base.

It is clear from molecular data that *Nama cuatrocienegensis* and *N. serpylloides* are very closely related, if not conspecific. They are both reported from the Cuatrocienegas basin in Coahuila (Figure 3.11 L and M), with *N. serpylloides* occurring on gypsum deposits and *N. cuatrocienegensis* appearing on "gravelly terraces" [from *J.L. Neff 92-3-29-1* (Holotype, LL)]. Only two specimens of *N. cuatrocienegensis* were available for examination: the holotype housed at TEX and cited above, and *Venable* and *McCormick 769* (LL; collected approximately 40 km south of Cuatrocienegas, and which we sampled for DNA), which was also determined by Nesom (1992a). Morphologically, the two specimens of *N. cuatrocienegensis* that we examined fall within the variation observed for *N. serpylloides.* The two species have been distinguished on the basis of vestiture (velvety in *N. serpylloides* vs. hirsute in *N. cuatrocienegensis*) and duration [*N. serpylloides* is perennial, while *N. cuatrocienegensis* is reportedly an ephemeral annual; Nesom (1992a)]. However, we have observed that *N. serpylloides* var. *serpylloides* generally has vestiture that is better described as hirsute, whereas *N. serpylloides* var. *velutina* is characterized by velvety indument. This leaves duration as the distinguishing factor between the two species. Further investigation may result in the synonymization of *N. cuatrocienegensis* under *N. serpylloides.*

As is the case with the *Nama jamaicensis* lineage, the *Nama serpylloides* lineage includes only one confirmed gypsophile, *Nama serpylloides.* Again, the question arises as to why only one species in this group has been collected from gypsum deposits. *Nama parvifolia* and *N. torynophylla* occur to the north and east of *N. serpylloides,* in south

Texas and Tamaulipas, occasionally in to northeastern Coahuila, geographically outside of the Chihuahuan Desert yet still in areas that range from semi-arid to arid. It is possible that *N. parvifolia* and *N. torynophylla* are able to become established on gypsum but have not had the opportunity.

Evolutionary relationships and the origin of gypsophily in the *Nama hispida* lineage

The *Nama hispida* clade is a group of ten species that includes three facultative gypsophiles, one obligate gypsophile, and six non-gypsophiles. The species *Nama hispida* is very variable morphologically and is widespread throughout the Chihuahuan Desert, spreading beyond its borders to the east and west (Figure 3.11N). We sampled several accessions of *Nama hispida* that all fell within the variation reported for the species, yet neither the chloroplast nor the ITS data sets recovered a monophyletic group for these samples. *Nama hispida* var. *sonorae* does not appear to be closely related to the other *N. hispida* accessions; clones from this variety form a strongly-supported (bs=100; PP=1.00) monophyletic group sister to the remaining species of the *Nama hispida* major clade (Figure 3.6). Further sampling and morphological study is required, but this entity may merit specific recognition. Although *Nama hispida* has been collected from a variety of substrates including gypsum, var. *sonorae* (which seems to be endemic to the Mexican state of Sonora, far outside the Chihuahuan Desert) has no reported association with gypsum and therefore was not marked as a gypsophile on figures or in analyses.

Within the *Nama hispida* clade of the ITS phylogeny, the clones of seven species all form monophyletic groups (*Nama undulata*, *N.* "*monclova*," (with the exception of 1 clone), *N. stevensii*, *N. coulteri*, *N. xylopoda*, and *N. retrorsa*; Figure 3.6). The clones of four species do not. Clones of *N. berlandieri* and *N. sandwicensis* are intermixed but collectively form a monophyletic group; in contrast, the chloroplast phylogeny places *N.*

sandwicensis sister to *N. hispida* var. *sonorae*. As stated above, *Nama hispida* itself is not a well-defined species, with the clones of all *Nama hispida* accessions (excluding var. *sonorae*) intermixed with clones of *N. turneri,* and these together forming a paraphyletic group due to the inclusion of *N. coulteri, N. xylopoda, N. stevensii, and N. "monclova*."

Analyses of both the chloroplast data set recovered the same derived clade of 6 species within the *Nama hispida* lineage. This clade is subtended in both the chloroplast and the ITS phylogenies by a grade composed of *N. berlandieri, N. sandwicense, N. undulata, N. retrorsa,* and *N. hispida* var. *sonorae*. The branching order of these species is incongruent between the two topologies, although bootstrap support in this region of the ITS tree is weak and only moderate in the chloroplast tree (Figures 3.4 and 3.6). While the incongruent relationships within this grade pose interesting evolutionary questions on their own, they do not affect observations on the evolution of gypsophily in the *Nama hispida* lineage, as all of the gypsophiles in this clade occur in the derived group of 6 species.

Both the chloroplast and ITS phylogenies recover a single clade within the *Nama hispida* lineage comprising all four gypsophiles plus two non-gypsophilic species (*N. coulteri* and *N. xylopoda*; Figures 3.4 and 3.6). The DELTRAN reconstruction of ancestral states for the chloroplast phylogeny infers two independent origins of facultative gypsophily within the *Nama hispida* lineage: first in the ancestor of *Nama hispida-107* and *N. hispida-195*, and then in the ancestor of *N. coulteri, N. turneri, N. "monclova," N. stevensii,* and the remaining accessions of *N. hispida*. This was followed by one change to non-gypsophily for *N. coulteri* and a change to obligate gypsophily for *N. stevensii.* Both the ACCTRAN and DELTRAN reconstructions of ancestral states for the ITS phylogeny and the ACCTRAN reconstruction for the chloroplast phylogeny infer a single origin of facultative gypsophily in the common ancestor of these six species, followed by a two changes to non-gypsophily for *N. coulteri* and *N. xylopoda* as well as a single transition to obligate gypsophily in *N. stevensii* or perhaps in the common ancestor of *N. stevensii* and *N. "monclova,"* should the latter species be determined to be obligately gypsophilic in the future. These two species are recovered as sister taxa by analyses of both data sets; given the paucity of substrate data for *N. "monclova"* we can not assert with certainty whether it is an obligate or a facultative gypsophile. Morphologically, *N. stevensii* and to a lesser extent *N. "monclova"* are intriguing because they are similar to *N. hispida* but have evolved narrow leaves that may be converging on the linear form typical of the species in the *Nama stenophylla* clade. *Nama stevensii* is almost certainly an obligate gypsophile. Interestingly, it is morphologically intermediate between the linear-leaved gypsum endemics of the *Nama stenophylla* clade and the non-gypsophile species of *Nama.* This species forms mats or low mounds and has narrowly elliptic or obovate leaves that approach a linear shape. *Nama stevensii* has been closely linked to *N. hispida*, with the only morphological character consistently able to distinguish between the two species being the nature of the pubescence, with *N. hispida* having erect, hispid hairs and *N. stevensii* having appressed vestiture (Tyrl et al. 1984).

CONCLUSIONS

Within *Nama,* both obligate and facultative gypsophily have arisen multiple times. We have discovered lineages in which gypsophiles have undergone a great deal of diversification and lineages where facultative gypsophiles have arisen just once. In the *Nama stenophylla* clade, obligate gypsophily has evolved three times from facultative gypsophile ancestors and calciphily has arisen once. The major changes in morphology, including increased woodiness, taller stature, and linear, terete, succulent leaves exhibited by most species of this lineage compared to the rest of *Nama*, colonization of gypsum deposits across the Chihuahuan Desert, and diversification into at least 10 species all point to a potentially great age for this lineage. While the facultative gypsophiles of the *Nama hispida* clade do not exhibit morphological changes of the magnitude of the *Nama stenophylla* clade species, its obligate gypsophile, *N. stevensii*, has converged on a similar narrow leaf shape and has colonized gypsum deposits from Monclova, Nuevo Leon (Mexico), to southwest Kansas (USA), a distance of over 1200 km. It is possible that despite giving rise to just one obligate gypsophile, the *Nama hispida* clade may have a long history inhabiting gypsum as well. Additional analyses are required to investigate this interesting possibility. Furthermore, efforts to clarify the substrate preferences of *N. "jimulco," N. johnstonii,* and *N. "monclova"* would enhance our understanding of the evolution of gypsophiles in *Nama.*

Table 3.1. List of all obligate (O) and facultative (F) gypsophiles within *Nama*. Asterisk denotes uncertain status: current evidence suggests affinity to gypsum, although whether the species noted is a facultative or obligate gypsophile is inconclusive given available data.

Species	Major Lineage	Status
Nama canescens	*Nama stenophylla* clade	O
N. carnosa	*Nama stenophylla* clade	O
N. constancei	*Nama stenophylla* clade	F
N. flavescens	*Nama stenophylla* clade	F
N. havardii	*Nama stenophylla* clade	F
N. hispida	*Nama hispidum* clade	F
N. hitchcockii	*Nama stenophylla* clade	F
N. johnstonii	*Nama stenophylla* clade	L
N. "monclova"	*Nama hispidum* clade	F*
N. "jimulco"	*Nama stenophylla* clade	F*
N. palmeri	*Nama jamaicense* clade	F
N. serpylloides	*Nama serpylloides* clade	F
N. stenophylla	*Nama stenophylla* clade	O
N. stevensii	*Nama hispida* clade	O
N. turneri	*Nama hispida* clade	F

Table 3.2. Topological hypotheses regarding the origins of gypsophily within *Nama*.

Hypothesis	**Species constrained to be monophyletic**
Monophyly of all gypsophiles, including *N. "jimulco"*	*Nama canescens, N. carnosa, N. constancei, N. flavescens, N. havardii, N. hispida, N. hitchcockii, N. "jimulco," N. "monclova", N. palmeri, N. turneri, N. serpylloides, N. stenophylla, N. stevensii*
Monophyly of all gypsophiles, excluding *N. "jimulco"*	*Nama canescens, N. carnosa, N. constancei, N. flavescens, N. havardii, N. hispida, N. hitchcockii, N. "monclova", N. palmeri, N. turneri, N. serpylloides, N. stenophylla, N. stevensii*
Monophyly of all obligate gypsophiles	*Nama canescens, N. carnosa, N. stenophylla, N. stevensii*
Monophyly of all facultative gypsophiles, including *N. "jimulco"*	*Nama constancei, N. flavescens, N. havardii, N. hispida, N. hitchcockii, N. "jimulco," N. "monclova", N. palmeri, N. turneri, N. serpylloides*
Monophyly of all facultative gypsophiles, excluding *N. "jimulco"*	*Nama constancei, N. flavescens, N. havardii, N. hispida, N. hitchcockii, N. "monclova", N. palmeri, N. turneri, N. serpylloides*
Monophyly of the obligate gypsophiles in the *Nama stenophylla* clade	*Nama canescens, N. carnosa, N. stenophylla*
Monophyly of the facultative gyspophiles in the *Nama stenophylla* clade, including *N. "jimulco"*	*Nama constancei, N. flavescens, N. havardii, N. hitchcockii, N. "jimulco"*
Monophyly of the facultative gypsophiles in the *Nama stenophylla* clade, excluding *N. "jimulco"*	*Nama constancei, N. flavescens, N. havardii, N. hitchcockii*
Monophyly of all gypsophiles in the *Nama hispida clade*	*Nama hispida, N. "monclova", N. turneri, N. stevensii*
Monophyly of the facultative gypsophiles in the *Nama hispida* clade	*Nama hispida, N. "monclova", N. turneri, N. stevensii*

Table 3.3. Results of hypothesis testing for the chloroplast data set. The significance level (α) was set to 0.05 for all tests prior to analysis. Hypotheses that were not rejected (p>0.05) are marked by †**.**

Hypothesis/constraint	**AU test p-value**	**SH test p-value**	**Weighted SH test p-value**	**SOWH test p-value**	**Bayesian PP**
Monophyly of all gypsophiles, including *N. “jimulco”*	<0.01	0	0	<0.01	0.00
Monophyly of all gypsophiles, excluding *N. “jimulco”*	<0.01	0	0	<0.01	0.00
Monophyly of all obligate gypsophiles	<0.01	0	0	<0.01	0.00
Monophyly of all facultative gypsophiles, including *N. “jimulco”*	<0.01	0	0	<0.01	0.00
Monophyly of all facultative gypsophiles, excluding *N. “jimulco”*	<0.01	0	0	<0.01	0.00
Monophyly of the obligate gypsophiles in the *Nama stenophylla* clade	<0.01	**0.169†**	<0.01	<0.01	0.00
Monophyly of the facultative gysophiles in the *Nama stenophylla* clade, including *N. “jimulco”*	<0.01	**0.279†**	<0.01	<0.01	0.00
Monophyly of the facultative gypsophiles in the *Nama stenophylla* clade, excluding *N. “jimulco”*	<0.01	**0.247†**	0.012	<0.01	0.00
Monophyly of all gypsophiles in the *Nama hispida clade*	<0.01	**0.557†**	**0.11†**	<0.01	0.00
Monophyly of the facultative gypsophiles in the *Nama hispida* clade	<0.01	**0.429†**	**0.058†**	<0.01	0.00

Table 3.4. Results of hypothesis testing for the ITS data set. The significance level (α) was set to 0.05 for all tests prior to analysis. Hypotheses that were not rejected (p>0.05) are marked by †**.**

Hypothesis/constraint	**AU test p-value**	**KH test p-value**	**SH test p-value**	**Weighted SH test p-value**	**SOWH test p-value**	**Bayesian PP**
Monophyly of all gypsophiles, including *N. "jimulco"*	<0.01	0	0	0	<0.01	0.00
Monophyly of all gypsophiles, excluding *N. "jimulco"*	<0.01	<0.01	**0.155†**	0.021	<0.01	0.00
Monophyly of all obligate gypsophiles	0.032	0.043	**0.513†**	**0.188†**	<0.01	0.00
Monophyly of all facultative gypsophiles, including *N. "jimulco"*	<0.01	0	0	0	<0.01	0.00
Monophyly of all facultative gypsophiles, excluding *N. "jimulco"*	<0.01	0	0	0	<0.01	0.00
Monophyly of the obligate gypsophiles in the *Nama stenophylla* clade	**0.17†**	0.02	**0.249†**	**0.093†**	<0.01	0.00
Monophyly of the facultative gyspophiles in the *Nama stenophylla* clade, including *N. "jimulco"*	<0.01	0	0	0	<0.01	0.00
Monophyly of the facultative gypsophiles in the *Nama stenophylla* clade, excluding *N. "jimulco"*	**0.083†**	**0.058†**	**0.397†**	**0.258†**	<0.01	0.00
Monophyly of all gypsophiles in the *Nama hispida clade*	<0.01	0	<0.01	0	<0.01	0.00
Monophyly of the facultative gypsophiles in the *Nama hispida* clade	<0.01	<0.01	**0.159†**	0.019	<0.01	0.00

Figure 3.1: Map of the Chihuahuan Desert, after Henrickson and Garcia (1976).

Figure 3.2: A and B; C – G continued on next pages.

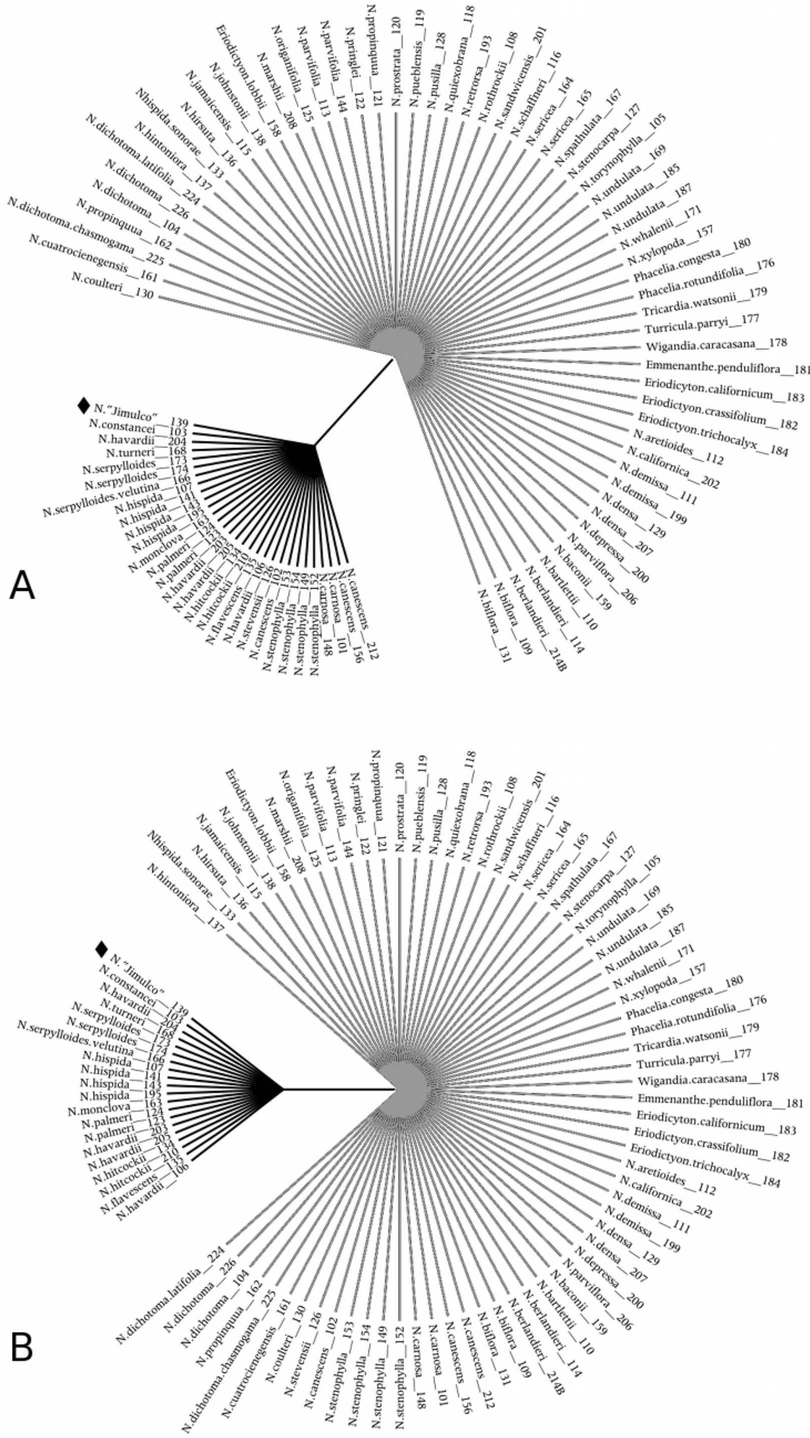


Figure 3.2: C and D; E – G continued on next pages.

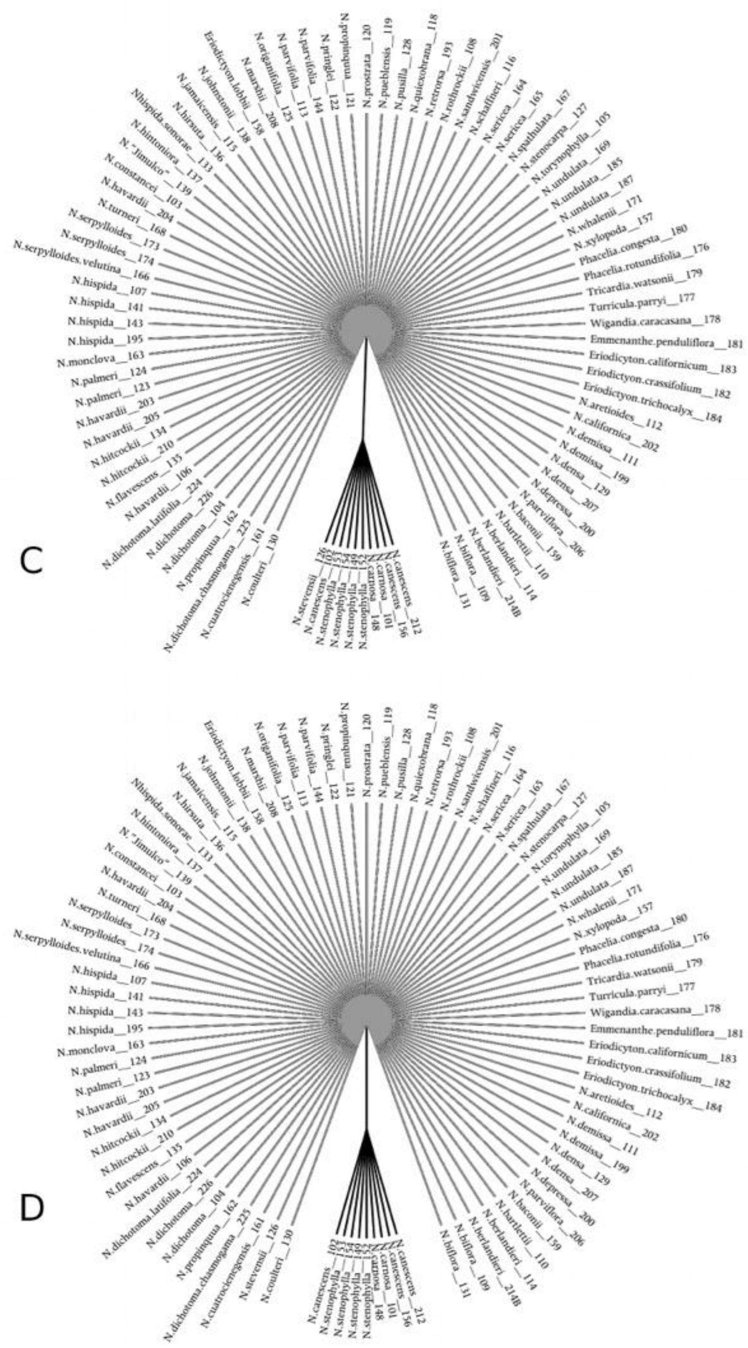
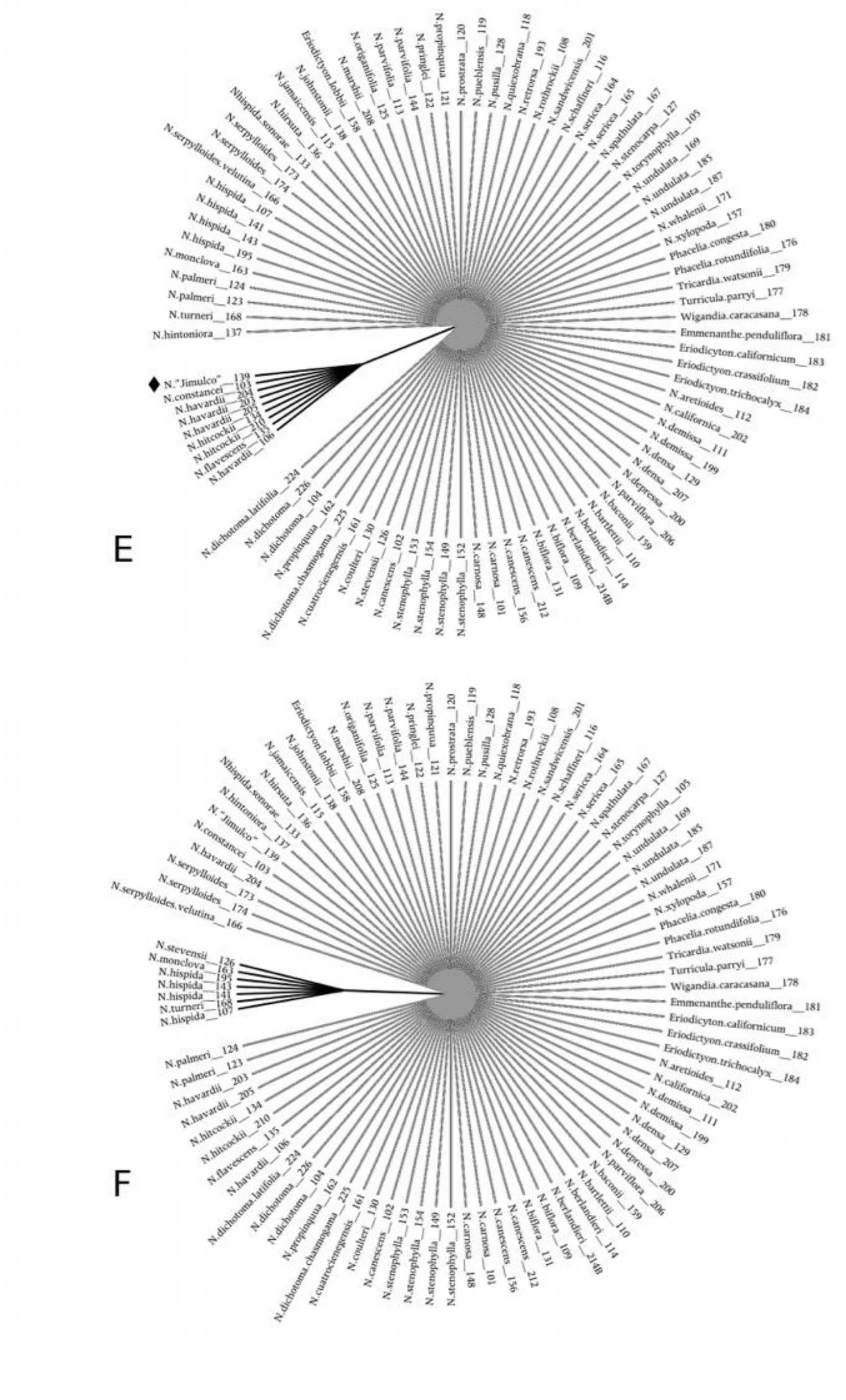


Figure 3.2: E and F; G continued on next page.



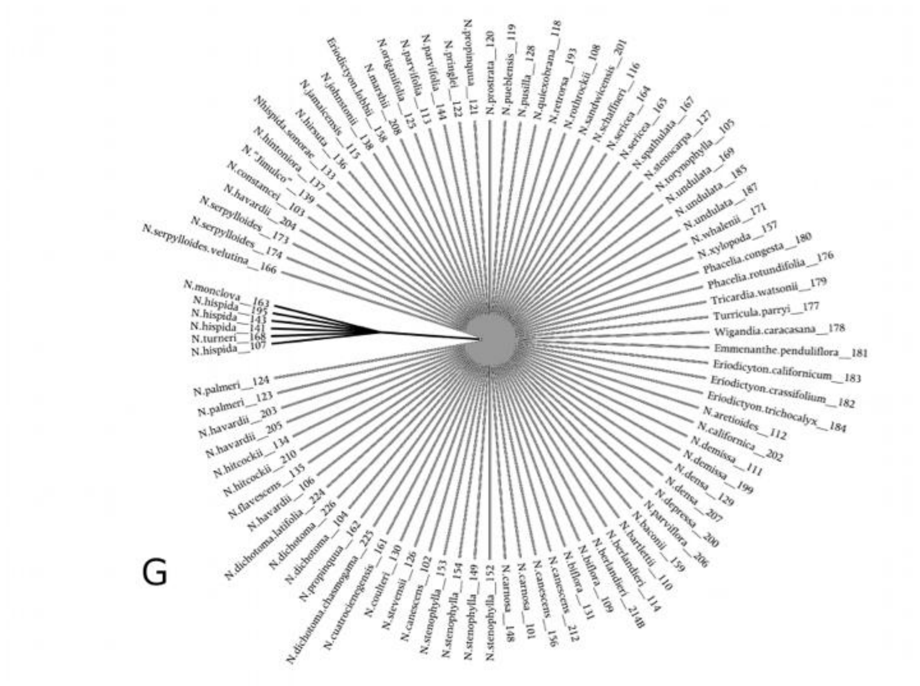


Figure 3.2: Constraint trees utilized to test hypotheses regarding the origin of gypsophily within *Nama* for the chloroplast data set. Constraint trees for the ITS data set were equivalent. A, monophyletic origin of all gypsophiles (this hypothesis was tested both including and excluding *Nama "jimulco,"* indicated by a solid diamond); B, monophyletic origin of all faculatative gypsophiles.; C, monophyletic origin of all obligate gypsophiles; D, monophyletic origin of the obligate gypsophiles of the *Nama stenophylla* lineage; E, monophyletic origin of the facultative gyspophiles of the *Nama stenophylla* lineage; F, monophyletic origin of all gysophiles of the *Nama hispida* lineage; G, monophyletic origin of the facultative gypsophiles of the *Nama hispida* lineage.

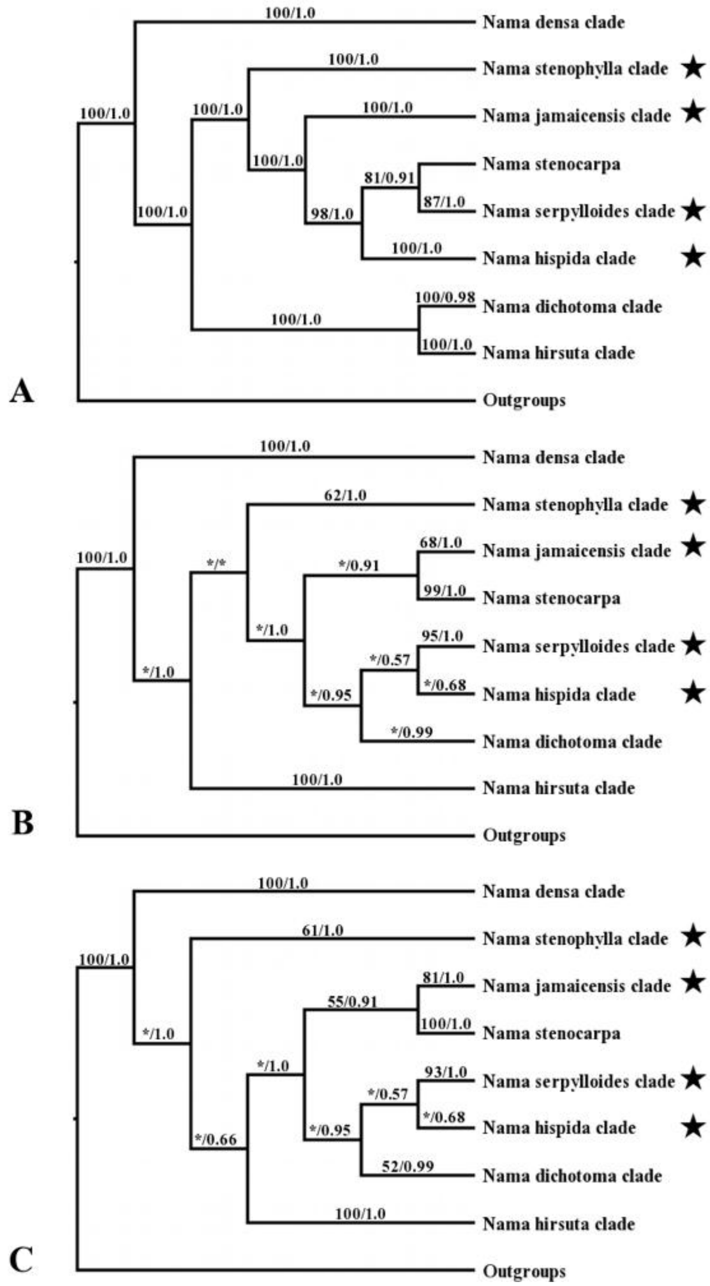


Figure 3.3: Major lineages of *Nama* recovered by ML analyses. Branch support values are given above branches, with ML bootstrap percentage (BP) followed by Bayesian posterior probability (PP). Asterisk (*) indicates value less than 50% BP or 0.5 PP. Lineages that contain one or more gypsophiles are marked with stars. A, Chloroplast topology recovered by GARLI and RAxML; B, ITS topology recovered by GARLI; C, ITS topology recovered by RAxML.

Figure 3.4.

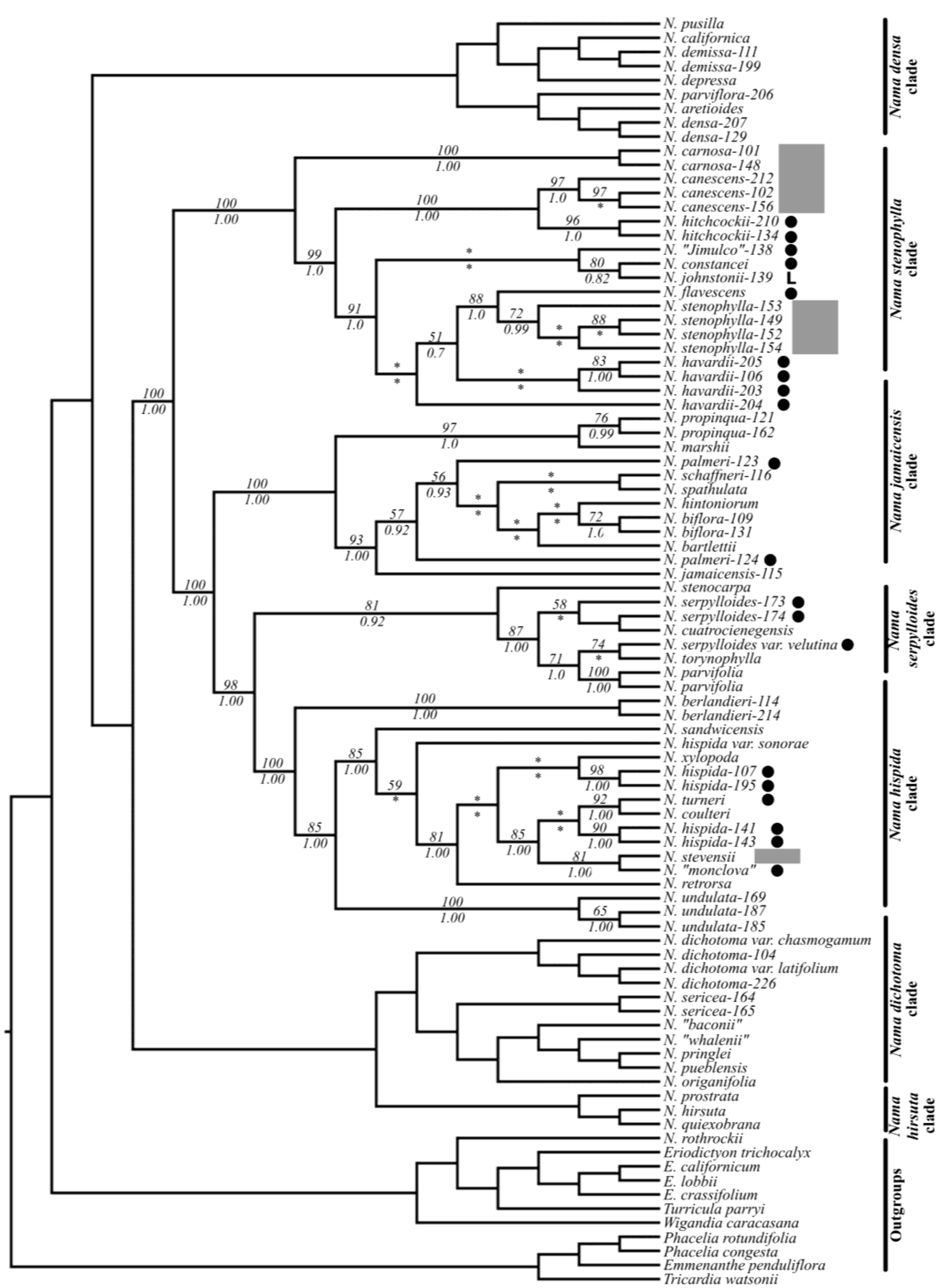

N. pusilla
N. californica
N. demissa-111
N. demissa-199
N. depressa
N. parviflora-206
N. aretioides
N. densa-207
N. densa-129
N. carnosa-101
N. carnosa-148
N. canescens-212
N. canescens-102
N. canescens-156
N. hitchcockii-210
N. hitchcockii-134
N. "Jimulco"-138
N. constancei
N. johnstonii-139
N. flavescens
N. stenophylla-153
N. stenophylla-149
N. stenophylla-152
N. stenophylla-154
N. havardii-205
N. havardii-106
N. havardii-203
N. havardii-204
N. propinqua-121
N. propinqua-162
N. marshii
N. palmeri-123
N. schaffneri-116
N. spathulata
N. hintoniorum
N. biflora-109
N. biflora-131
N. bartlettii
N. palmeri-124
N. jamaicensis-115
N. stenocarpa
N. serpylloides-173
N. serpylloides-174
N. cuatrocienegensis
N. serpylloides var. velutina
N. torynophylla
N. parvifolia
N. parvifolia
N. berlandieri-114
N. berlandieri-214
N. sandwicensis
N. hispida var. sonorae
N. xylopoda
N. hispida-107
N. hispida-195
N. turneri
N. coulteri
N. hispida-141
N. hispida-143
N. stevensii
N. "monclova"
N. retrorsa
N. undulata-169
N. undulata-187
N. undulata-185
N. dichotoma var. chasmogamum
N. dichotoma-104
N. dichotoma var. latifolium
N. dichotoma-226
N. sericea-164
N. sericea-165
N. "baconii"
N. "whalenii"
N. pringlei
N. pueblensis
N. origanifolia
N. prostrata
N. hirsuta
N. quiexobrana
N. rothrockii
Eriodictyon trichocalyx
E. californicum
E. lobbii
E. crassifolium
Turricula parryi
Wigandia caracasana
Phacelia rotundifolia
Phacelia congesta
Emmenanthe penduliflora
Tricardia watsonii
Nama densa clade
Nama stenophylla clade
Nama jamaicensis clade
Nama serpylloides clade
Nama hispida clade
Nama dichotoma clade
Nama hirsuta clade
Outgroups

Figure 3.4: Incidence of gypsophily mapped on to the maximum likelihood cladogram obtained from analyses of the chloroplast data set using RAxML and GARLI. Black circles indicate the position of facultative gypsophiles; obligate gypsophiles are indicated by gray boxes. *Nama johnstonii*, a limestone endemic, is indicated with a letter "L." RAxML bootstrap percentages above 50% are noted above branches (out of 6100 replicates; values from GARLI analysis were similar); posterior probabilities about 0.5 are noted below. Asterisks above and below branches indicate <50% BP and <0.5 PP, respectively. Support values are not given for clades that do not include any gypsophiles.

Figure 3.5.

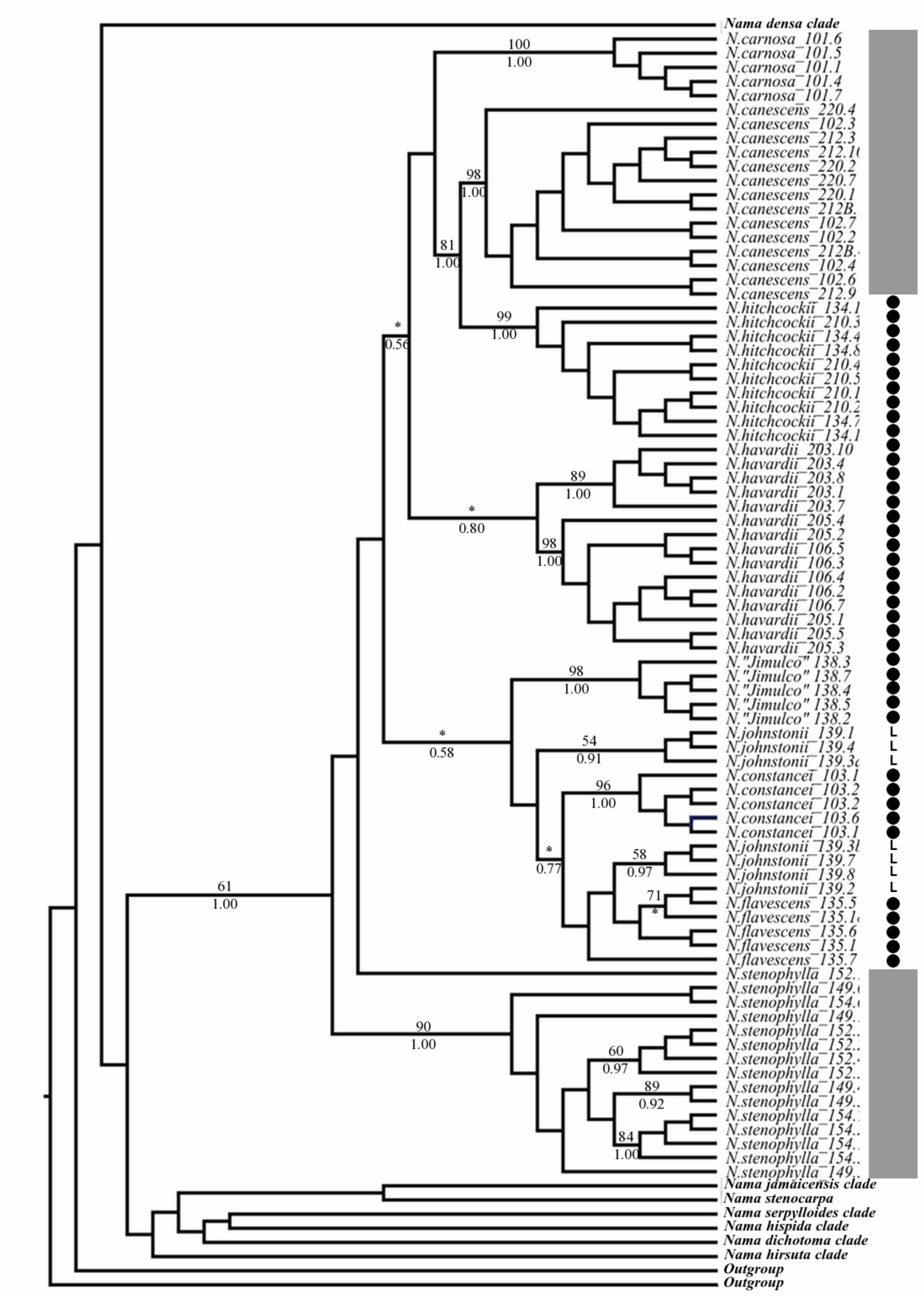

Nama densa clade
N.carnosa_101.6
N.carnosa_101.5
N.carnosa_101.1
N.carnosa_101.4
N.carnosa_101.7
N.canescens_220.4
N.canescens_102.3
N.canescens_212.3
N.canescens_212.1
N.canescens_220.2
N.canescens_220.7
N.canescens_220.1
N.canescens_212B.
N.canescens_102.7
N.canescens_102.2
N.canescens_212B.
N.canescens_102.4
N.canescens_102.6
N.canescens_212.9
N.hitchcockii_134.1
N.hitchcockii_210.3
N.hitchcockii_134.4
N.hitchcockii_134.8
N.hitchcockii_210.4
N.hitchcockii_210.5
N.hitchcockii_210.1
N.hitchcockii_210.2
N.hitchcockii_134.7
N.hitchcockii_134.1
N.havardii_203.10
N.havardii_203.4
N.havardii_203.8
N.havardii_203.1
N.havardii_203.7
N.havardii_205.4
N.havardii_205.2
N.havardii_106.5
N.havardii_106.3
N.havardii_106.4
N.havardii_106.2
N.havardii_106.7
N.havardii_205.1
N.havardii_205.5
N.havardii_205.3
N."Jimulco" 138.3
N."Jimulco" 138.7
N."Jimulco" 138.4
N."Jimulco" 138.5
N."Jimulco" 138.2
N.johnstonii_139.1
N.johnstonii_139.4
N.johnstonii_139.3
N.constancei_103.1
N.constancei_103.2
N.constancei_103.2
N.constancei_103.6
N.constancei_103.1
N.johnstonii_139.3
N.johnstonii_139.7
N.johnstonii_139.8
N.johnstonii_139.2
N.flavescens_135.5
N.flavescens_135.1
N.flavescens_135.6
N.flavescens_135.1
N.flavescens_135.7
N.stenophylla_152.
N.stenophylla_149.
N.stenophylla_154.
N.stenophylla_149.
N.stenophylla_152.
N.stenophylla_152.
N.stenophylla_152.
N.stenophylla_152.
N.stenophylla_149.
N.stenophylla_149.
N.stenophylla_154.
N.stenophylla_154.
N.stenophylla_154.
N.stenophylla_154.
N.stenophylla_149.
Nama jamaicensis clade
Nama stenocarpa
Nama serpylloides clade
Nama hispida clade
Nama dichotoma clade
Nama hirsuta clade
Outgroup
Outgroup
100
1.00
98
1.00
81
1.00
99
1.00
*
0.56
89
1.00
*
0.80
98
1.00
98
1.00
*
0.58
54
0.91
96
1.00
*
0.77
58
0.97
71
*
61
1.00
90
1.00
60
0.97
89
0.92
84
1.00

Figure 3.5. Incidence of gypsophily mapped on to the *Nama stenophylla* clade as recovered by ML analyses of the ITS data set. Notation for gypsophiles is as in Figure 3.1. Bootstrap values (out of 8100 replicates) and posterior probabilities are noted above and below branches for this clade only; asterisks indicate BS or PP values below 50% or 0.50, respectively. Branches with no support values indicated have BS or PP values below 50% or 0.50, respectively.

Figure 3.6.

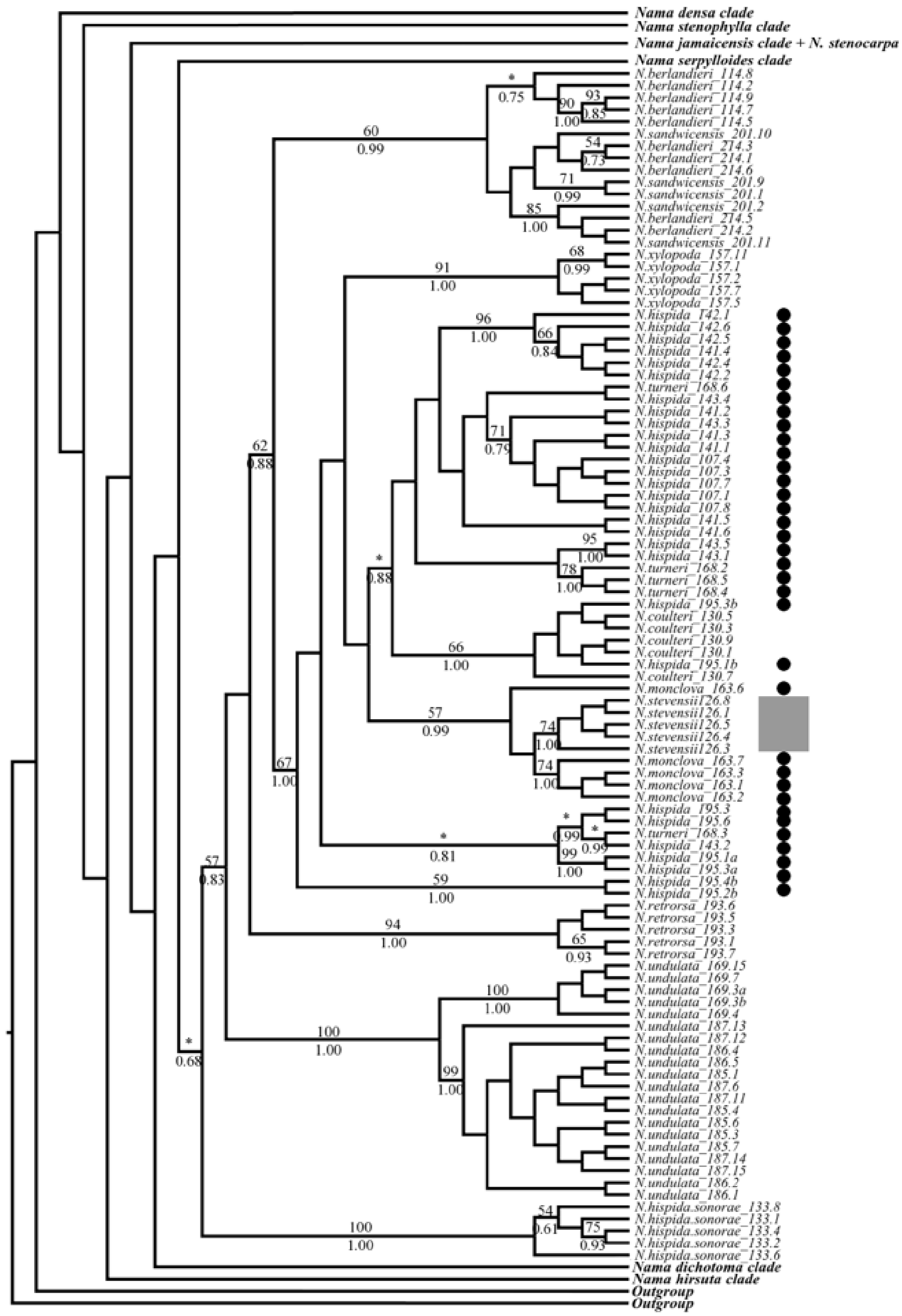

Nama densa clade
Nama stenophylla clade
Nama jamaicensis clade + N. stenocarpa
Nama serpylloides clade
N.berlandieri_114.8
N.berlandieri_114.2
N.berlandieri_114.9
N.berlandieri_114.7
N.berlandieri_114.5
N.sandwicensis_201.10
N.berlandieri_214.3
N.berlandieri_214.1
N.berlandieri_214.6
N.sandwicensis_201.9
N.sandwicensis_201.1
N.sandwicensis_201.2
N.berlandieri_214.5
N.berlandieri_214.2
N.sandwicensis_201.11
N.xylopoda_157.11
N.xylopoda_157.1
N.xylopoda_157.2
N.xylopoda_157.7
N.xylopoda_157.5
N.hispida_142.1
N.hispida_142.6
N.hispida_142.5
N.hispida_141.4
N.hispida_142.4
N.hispida_142.2
N.turneri_168.6
N.hispida_143.4
N.hispida_141.2
N.hispida_143.3
N.hispida_141.3
N.hispida_141.1
N.hispida_107.4
N.hispida_107.3
N.hispida_107.7
N.hispida_107.1
N.hispida_107.8
N.hispida_141.5
N.hispida_141.6
N.hispida_143.5
N.hispida_143.1
N.turneri_168.2
N.turneri_168.5
N.turneri_168.4
N.hispida_195.3b
N.coulteri_130.5
N.coulteri_130.3
N.coulteri_130.9
N.coulteri_130.1
N.hispida_195.1b
N.coulteri_130.7
N.monclova_163.6
N.stevensii126.8
N.stevensii126.1
N.stevensii126.5
N.stevensii126.4
N.stevensii126.3
N.monclova_163.7
N.monclova_163.3
N.monclova_163.1
N.monclova_163.2
N.hispida_195.3
N.hispida_195.6
N.turneri_168.3
N.hispida_143.2
N.hispida_195.1a
N.hispida_195.3a
N.hispida_195.4b
N.hispida_195.2b
N.retrorsa_193.6
N.retrorsa_193.5
N.retrorsa_193.3
N.retrorsa_193.1
N.retrorsa_193.7
N.undulata_169.15
N.undulata_169.7
N.undulata_169.3a
N.undulata_169.3b
N.undulata_169.4
N.undulata_187.13
N.undulata_187.12
N.undulata_186.4
N.undulata_186.5
N.undulata_185.1
N.undulata_187.6
N.undulata_187.11
N.undulata_185.4
N.undulata_185.6
N.undulata_185.3
N.undulata_185.7
N.undulata_187.14
N.undulata_187.15
N.undulata_186.2
N.undulata_186.1
N.hispida.sonorae_133.8
N.hispida.sonorae_133.1
N.hispida.sonorae_133.4
N.hispida.sonorae_133.2
N.hispida.sonorae_133.6
Nama dichotoma clade
Nama hirsuta clade
Outgroup
Outgroup

Figure 3.6: Incidence of gypsophily mapped on to the *Nama hispida* clade as recovered by ML analyses of the ITS data set. Notation for gypsophiles is as in Figure 3.1. Bootstrap values (out of 8100 replicates) and posterior probabilities are noted above and below branches for this clade only; asterisks indicate BS or PP values below 50% or 0.50, respectively. Branches with no support values indicated have BS or PP values below 50% or 0.50, respectively.

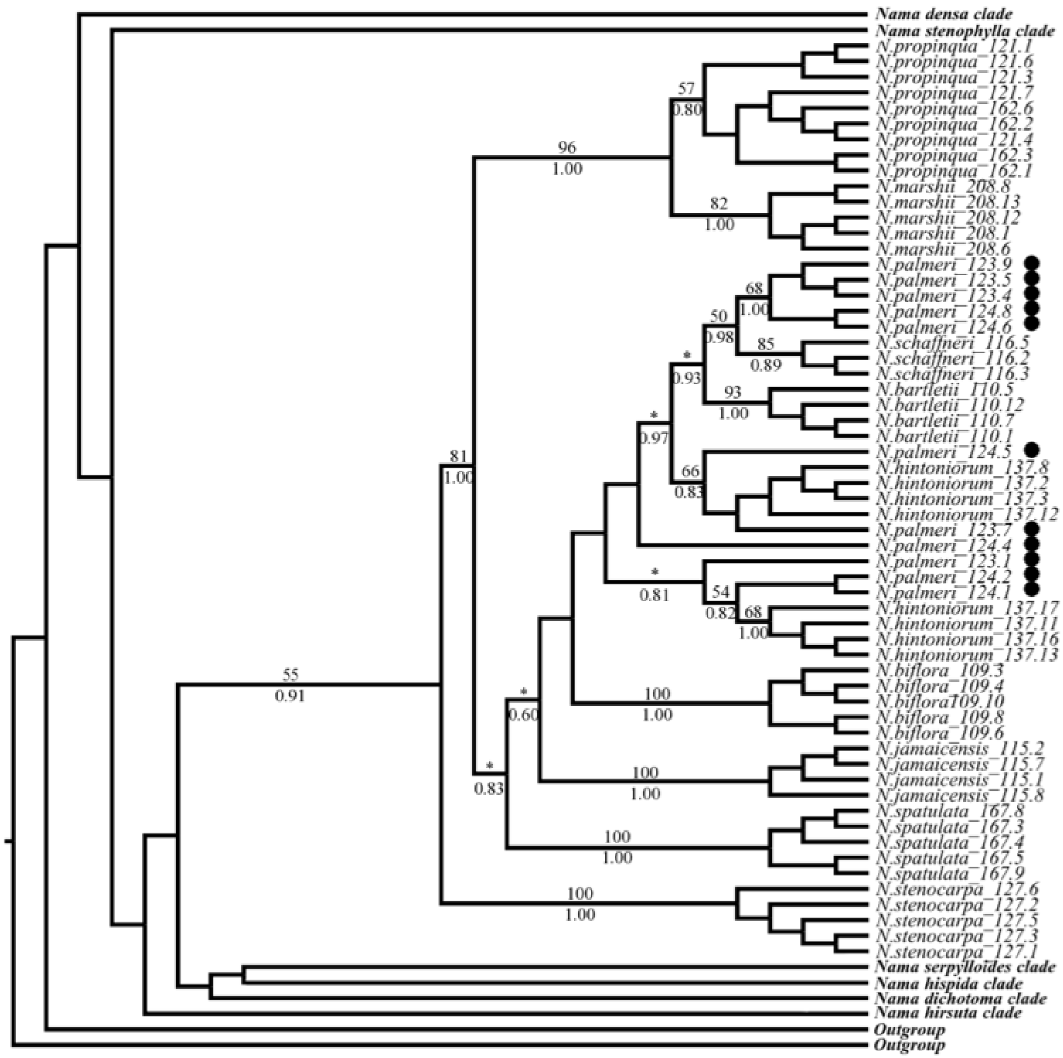


Figure 3.7: Incidence of gypsophily mapped on to the *Nama jamaicensis* clade as recovered by ML analyses of the ITS data set. Black dots mark the position of clones of *N. palmeri*, the single facultative gypsophile known from this clade. Bootstrap values (out of 8100 replicates) and posterior probabilities are noted above and below branches for this clade only; asterisks indicate BS or PP values below 50% or 0.50, respectively. Branches without support values have BS or PP values below 50% or 0.50.

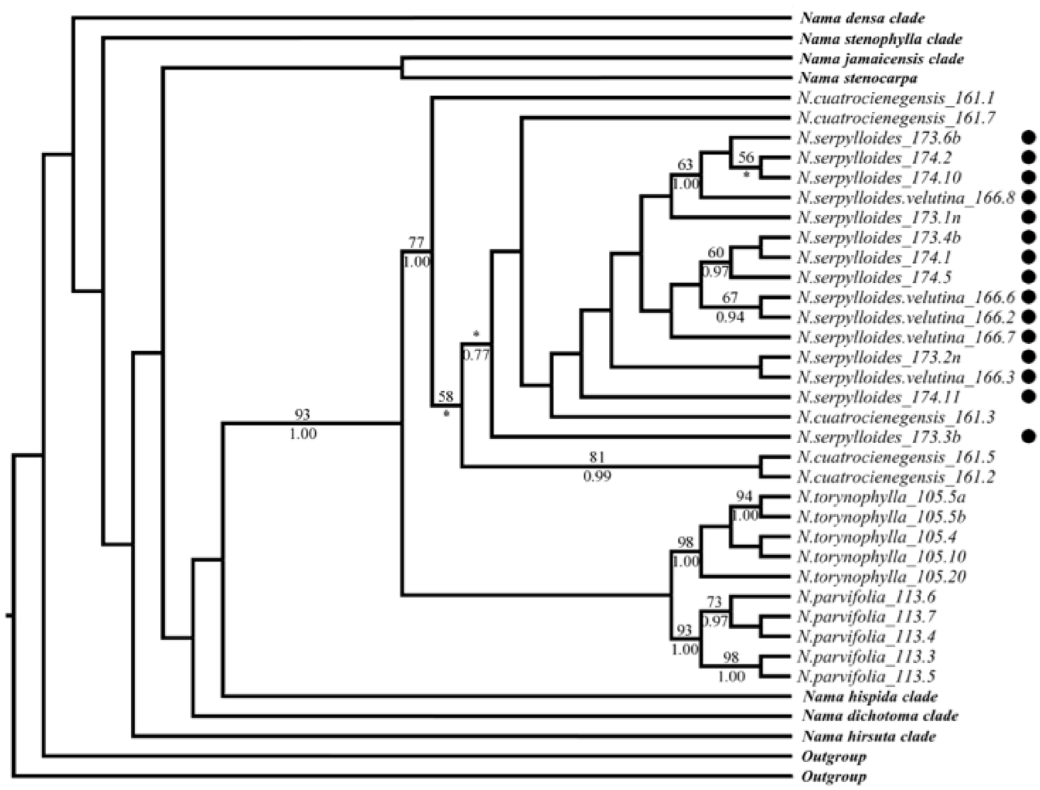


Figure 3.8. Incidence of gypsophily mapped on to the *Nama serpylloides* clade as recovered by ML analyses of the ITS data set. Black dots mark the position of clones of N. serpylloides, the single facultative gypsophile known from this clade. Bootstrap values (out of 8100 replicates) and posterior probabilities are noted above and below branches for this clade only; asterisks indicate BS or PP values below 50% or 0.50, respectively. Branches without support values have BS or PP values below 50% or 0.50.

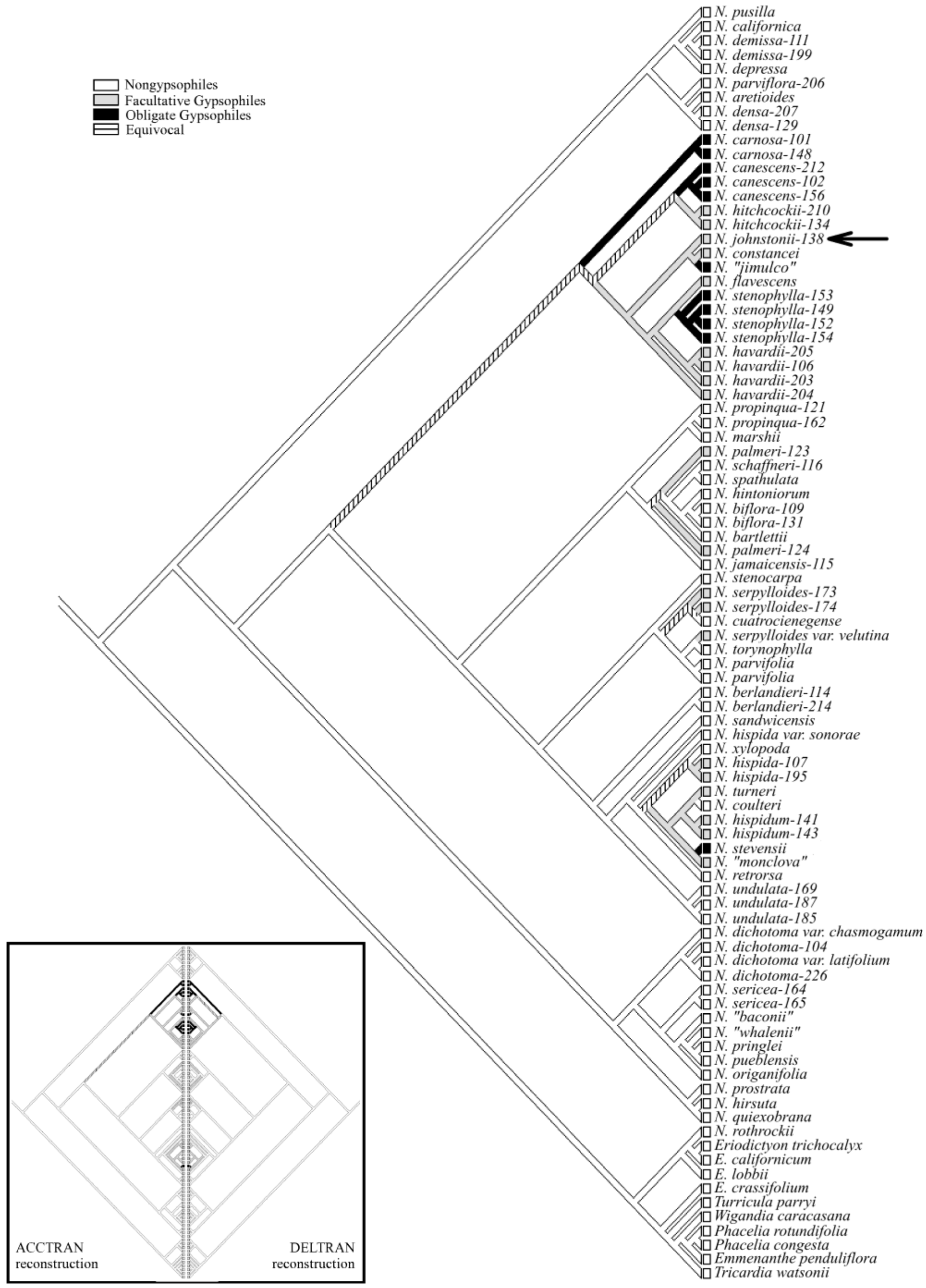


Figure 3.9: Consensus of 32 most parsimonious ancestral state reconstructions of facultative and obligate gypsophily mapped on to the best-scoring ML phylogeny of the chloroplast data set. Arrow denotes the position of *Nama johnstonii,* a limestone endemic. The inset illustrates the ACCTRAN and DELTRAN reconstructions of gypsophily.

Figure 3.10

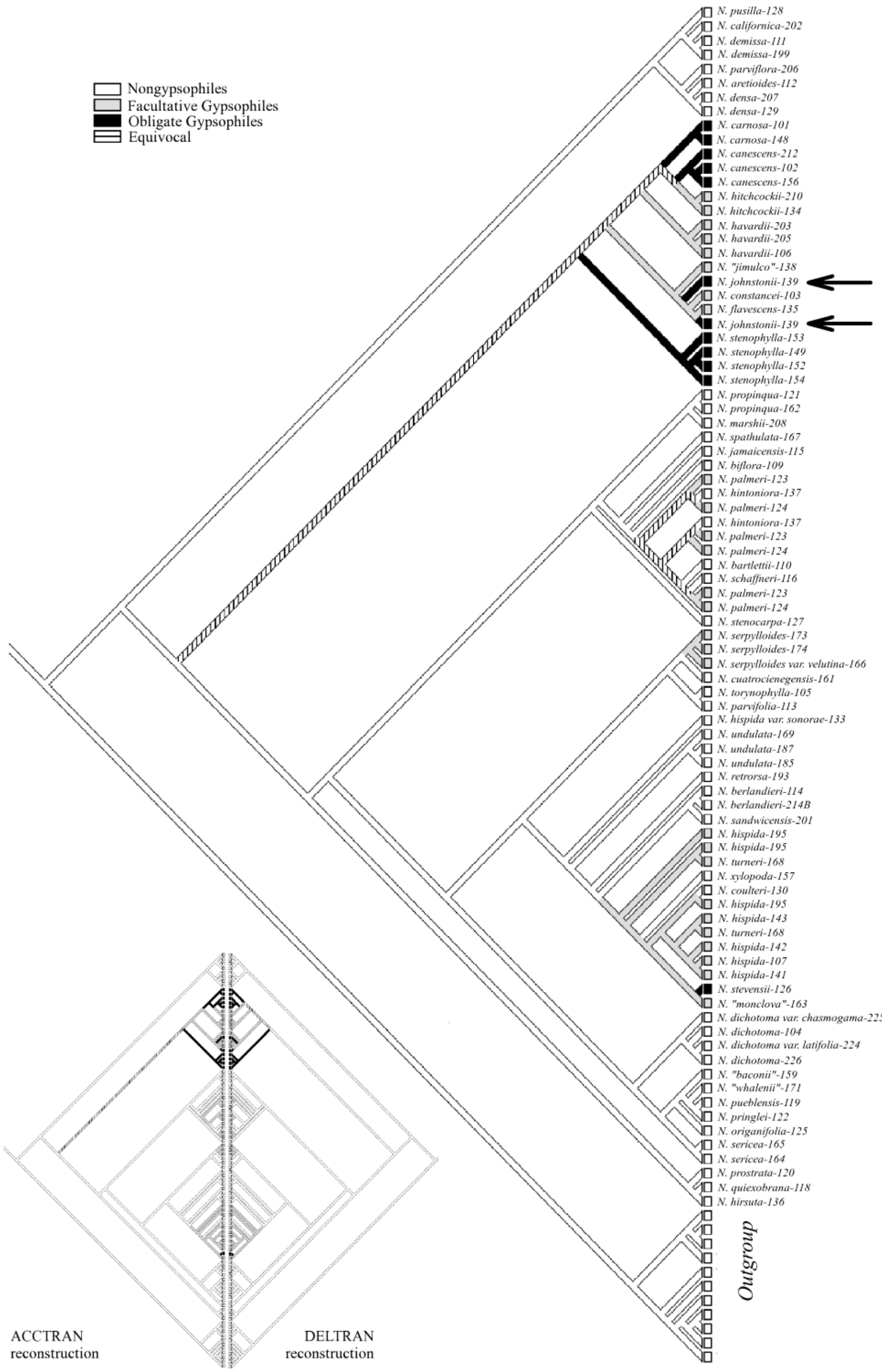
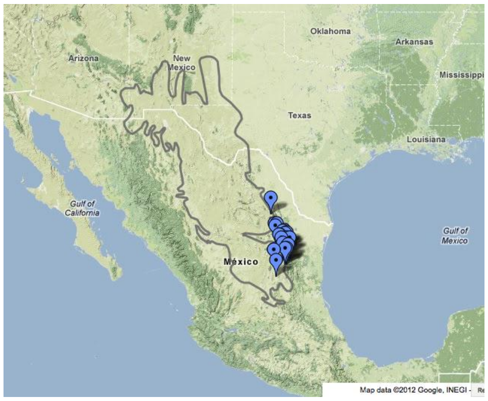
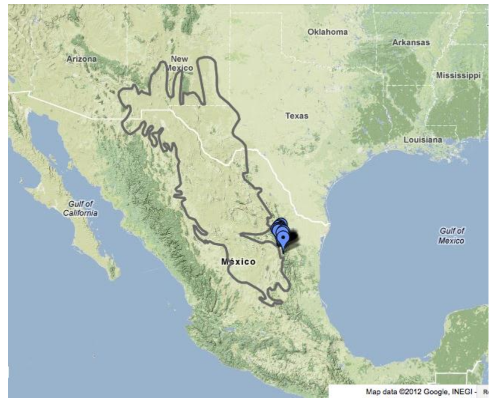

Nongypsophiles
Facultative Gypsophiles
Obligate Gypsophiles
Equivocal
N. pusilla-128
N. californica-202
N. demissa-111
N. demissa-199
N. parviflora-206
N. aretioides-112
N. densa-207
N. densa-129
N. carnosa-101
N. carnosa-148
N. canescens-212
N. canescens-102
N. canescens-156
N. hitchcockii-210
N. hitchcockii-134
N. havardii-203
N. havardii-205
N. havardii-106
N. "jimulco"-138
N. johnstonii-139
N. constancei-103
N. flavescens-135
N. johnstonii-139
N. stenophylla-153
N. stenophylla-149
N. stenophylla-152
N. stenophylla-154
N. propinqua-121
N. propinqua-162
N. marshii-208
N. spathulata-167
N. jamaicensis-115
N. biflora-109
N. palmeri-123
N. hintoniora-137
N. palmeri-124
N. hintoniora-137
N. palmeri-123
N. palmeri-124
N. bartlettii-110
N. schaffneri-116
N. palmeri-123
N. palmeri-124
N. stenocarpa-127
N. serpylloides-173
N. serpylloides-174
N. serpylloides var. velutina-166
N. cuatrocienegensis-161
N. torynophylla-105
N. parvifolia-113
N. hispida var. sonorae-133
N. undulata-169
N. undulata-187
N. undulata-185
N. retrorsa-193
N. berlandieri-114
N. berlandieri-214B
N. sandwicensis-201
N. hispida-195
N. hispida-195
N. turneri-168
N. xylopoda-157
N. coulteri-130
N. hispida-195
N. hispida-143
N. turneri-168
N. hispida-142
N. hispida-107
N. hispida-141
N. stevensii-126
N. "monclova"-163
N. dichotoma var. chasmogama-225
N. dichotoma-104
N. dichotoma var. latifolia-224
N. dichotoma-226
N. "baconii"-159
N. "whalenii"-171
N. pueblensis-119
N. pringlei-122
N. origanifolia-125
N. sericea-165
N. sericea-164
N. prostrata-120
N. quiexobrana-118
N. hirsuta-136
Outgroup
ACCTRAN reconstruction
DELTRAN reconstruction

Figure 3.10: Consensus of 42 most parsimonious ancestral state reconstructions of facultative and obligate gypsophily mapped on to the best-scoring ML phylogeny of the chloroplast data set. Cloned ITS sequences have been pruned from the tree, leaving representative clones consistent with the full tree. Arrows denote the positions of *Nama johnstonii,* a limestone endemic. The inset illustrates the ACCTRAN and DELTRAN reconstructions of gypsophily.

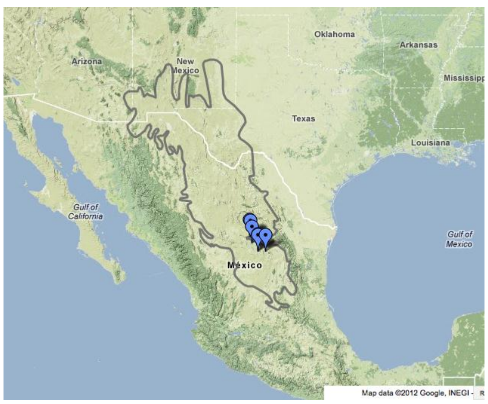
Figure 3.11 A – F; G – N on following pages.



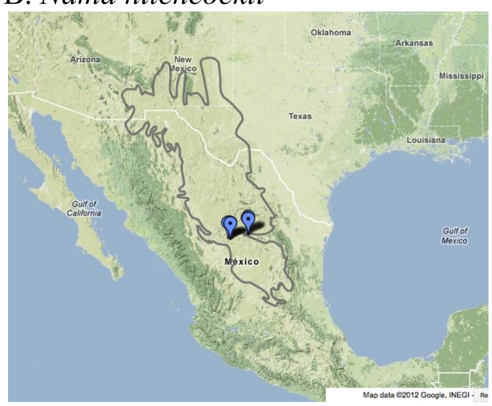
A. *Nama canescens*



B. *Nama hitchcockii*



C. *Nama flavescens*



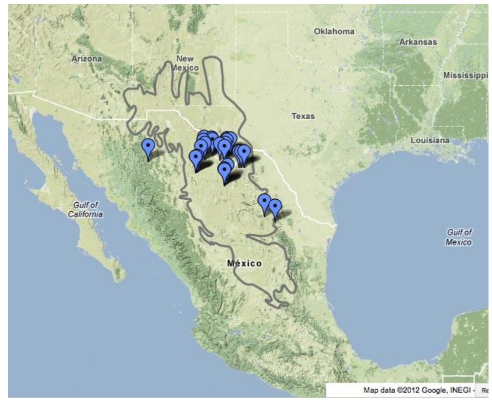
D. *Nama johnstonii*

E. *Nama carnosa*

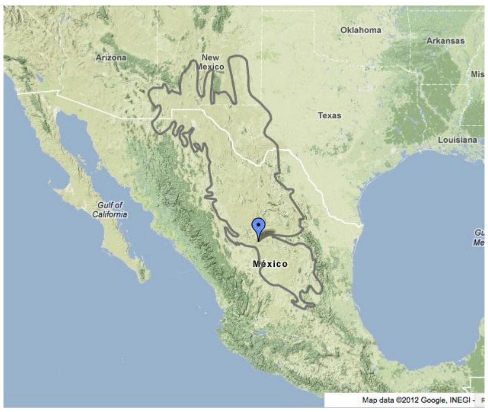
F. *Nama stenophylla*

Figure 3.11 G – L; M – N on following pages.

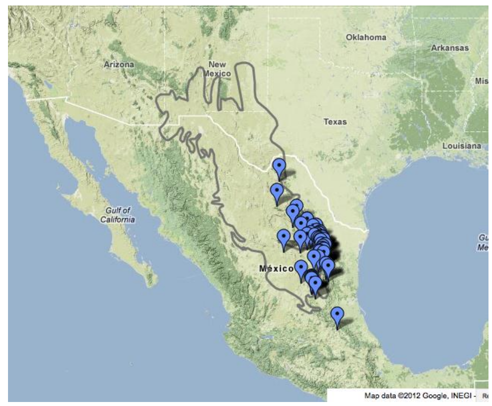
G. *Nama constancei*



H. *Nama havardii*



I. *Nama "jimulco"*



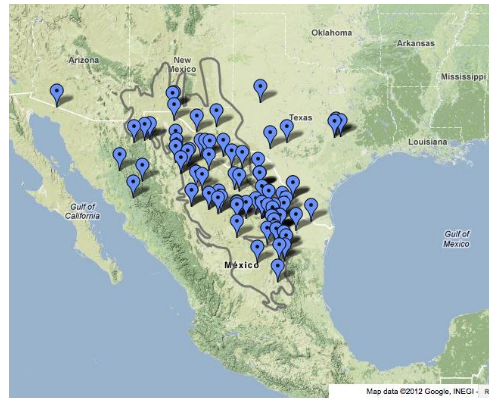
J. *Nama palmeri*

K. *Nama hintoniora*

L. *Nama serpylloides*

Figure 3.11 M - N

M. *Nama cuatrocienegensis*



N. *Nama hispida*

Figure 3.11: Geographic distribution of gypsophiles in the genus *Nama*. Gray outline delineates the Chihuahuan Desert, after Henrickson and Garcia (1976). *Nama johnstonii* (I) was included based on its close relationship to gypsophiles in the *Nama stenophylla* major lineage; it is endemic to limestone rather than to gypsum.

Chapter 4: A key to the species of *Nama* (Boraginaceae) and revision of the *Nama stenophylla* clade

INTRODUCTION

Nama L. comprises 52 species and 18 varieties as well as four putative new species (in prep) distributed across New World deserts and arid regions as well as coastal and montane habitats. Three species have been collected from both North and South America, one species is endemic to the Hawaiian Islands, and the remaining 52 species range from the west coast of the United States, south as far as Honduras, and east through the Caribbean Islands (Table 4.1).

The key presented in this chapter is the first to include all species in the genus since Hitchcock's 1933 monograph of *Nama*. In the intervening 79 years, 22 species and six varieties have been described in 16 publications, necessitating production of a new key for species identification. The key and an accompanying revision of the *Nama stenophylla* clade, a group of nine Chihuahuan Desert species endemic to gypsum and limestone deposits, are based on the detailed examination of several hundred herbarium specimens, molecular phylogenetic analyses, and field observations.

Origin of the genus and taxonomic history

The generic name *Nama* is conserved, (McNeill et al. 2006), with the earlier name "*Nama*" applied to an Old World species (*N. zaylanica*) described by Linnaeus (1753) that is now treated as *Hydrolea zeylanica*. *Nama* as currently applied dates to 1759, when Linnaeus described *N. jamaicensis* based on a "spreading hairy *Nama*" from Jamaica described by Patrick Browne with very detailed illustrations by Ehret (Browne 1756; illustration at Tab. 18. f. 2). Asa Gray, Jacques Choisy, John Lemmon, and Carl Ludwig von Willdenow made major contributions to the taxonomy of *Nama* over the next hundred years (Table 4.2).

At the end of the nineteenth century, Kuntze (1891) published the first volume of his *Revisio Generum Plantarum*, wherein he treated Linnaeus's (1735) *Systema Naturae* as the nomenclatural starting point for botanical names and instituted a policy of strict priority for names, asserting that he was implementing De Candolle's (1867) "Laws of Botanical Nomenclature" (Weatherby 1949). In the three volumes of the *Revisio*, Kuntze proposed 1,074 generic name changes and 30,000 new combinations, sparking "a nomenclatural schism of the first order" (Nicolson 1991). Because the first species assigned to *Nama*, *N. zaylanica*, had been transferred to *Hydrolea*, Kuntze reassigned all species within *Hydrolea* to *Nama* and erected a new genus, *Marilaunidium*, to circumscribe the group of species that had included *Nama jamaicensis*.

Among other developments, the International Botanical Congress that convened in Vienna in 1905 voted to conserve the names of several hundred genera (Arthur et al. 1907, Weatherby 1949), accepting the common usage of the names at that time rather than adopting a policy of strict priority. Both *Nama* (based on *N. jamaicensis*) and *Hydrolea* (based on *H. spinosa* and including *H. zeylanica*) were conserved by this ruling, reversing Kuntze's generic assignments. However, followers of the American (or Brittonian) Code were infuriated by the "failure to recognize the basic principle of generic types, and the absurd recommendation to make exceptions from the rules adopted in the case of over 400 generic names…" (Earle 1905, Arthur et al. 1907, Nicolson 1991) and continued to use the generic names *Nama* and *Marilaunidium* as circumscribed by Kuntze. Some American botanists (Britton and Brown 1913; Small, 1913, 1933; but not Jepson 1925) maintained this usage until the International Botanical Congress at Cambridge in 1930, when a compromise brokered by A.S. Hitchcock was accepted and followers of the American Code finally assented on the matter of nomenclatural conservation (Blackwell 2002) .

Complicating matters even further, Heller (1898) moved 12 species from *Nama* into the genus *Conanthus* S. Watson, which had been erected pre-*Revisio* in 1871. Brand (1913) then erected the monotypic genus *Andropus* based on *Conanthus carnosus* (Hook. & Arn.) Wooton, basing the new genus on his interpretation of the filament bases. Additionally, MacBride (1917) transferred *Nama parryi* to his proposed new genus *Turricula*. By the time Hitchcock (1933a,b) revised the genus there were at least 80 specific epithets distributed among five genera that could arguably be associated with the name *Nama*. Many of these epithets were combinations that had resulted from Kuntze's (1891) nomenclatural *coup d'état* and were listed in Hitchcock's revision as "doubtful or excluded species" by virtue of their synonymy with species of *Hydrolea*. Hitchcock's 1933 treatment recognized 32 species, and together with his subsequent emendation adding another four species (Hitchcock 1939), constituted the last major revisionary works on the genus.

Etymology, gender, and species epithets

The generic name *Nama* is derived from the Greek *nama* or *namatos*, meaning "anything flowing, running water, stream, spring" (Liddell and Scott 1940). While most species of *Nama* grow in deserts or dry upland habitats, *Hydrolea zeylanica* (the type species of pre-conserved *Nama*) is an aquatic plant that grows along pond margins, stream sides, and rice paddies. Coincidentally, the type species of *Nama* as conserved, *N. jamaicensis*, is one of the few species in the genus that does grow on damp stream banks.

The gender of *Nama* has been treated variously as neutral or feminine throughout the history of the genus. Linnaeus (1753) designated feminine endings for the species epithets *zaylanica* and *jamaicensis*. Subsequent authors continued to use feminine endings for species names (Choisy 1833, 1846; Gray 1860, 1870). In his 1875 treatment of the Hydrophyllaceae, Gray noted, “The generic name [*Nama*], both in Latin and Greek, is of the neuter gender.” Since then, treatments and floras have employed neuter endings for species epithets in *Nama* (for example, Gray 1875, 1882, 1884; Brand 1913, Jepson 1925, Hitchcock 1933a, b, 1939; Johnston 1941a,b) and the matter appeared to be settled. However, the gender question arose again in the 1990s with two papers (Manara 1991; Nicolson 1994) addressing generic names derived from Greek words ending in –ma. Manara (1991) indicated that most Greek words ending in –ma produce neuter generic names; a long list of exceptions to this general rule did not include *Nama*, implying that Manara would assign neutral gender to the genus. Nicolson (1994) asserted that generic names listed in dictionaries with extended neuter stems (e.g., *-atos* in Greek) should be accepted as neuter, but then explicitly assigned a feminine gender to *Nama*, apparently based on the original Linnaean (1753, 1759) publications. Under ICBN Art. 62.1 (McNeill et al. 2006), a generic name retains the gender assigned by botanical tradition. If it lacks a botanical tradition, it retains the gender assigned by its author. “Botanical tradition” has been accepted to refer to names in use before Linnaeus; thus, *Nama* has no botanical tradition in the customary sense (the name first appears in Linnaeus’s *Flora Zeylanica* {1747}) and it retains a feminine gender per Linnaeus’s original assignment (Fred Barrie, pers. comm.).

Placement of *Nama* in Boraginaceae *s.l.*

A.L. de Jussieu assigned *Nama* to “Ordo Convolvuli” (1789). Subsequently, Robert Brown erected the families Hydrophylleae and Hydroleae, comprising selected genera from de Jussieu’s “Ordo Boragineae” and “Ordo Convolvuli” respectively (Ferguson 1998). The two families were united by Gray (1875) under the name Hydrophyllaceae (R. Br.) Lindley. Based on molecular data, the Hydrophyllaceae is divided into two major clades, Clade I and Clade II (Ferguson 1998a,b). Clade II comprises two subclades: a monophyletic *Nama* (excluding *N. rothrockii*), and a clade containing the genera *Eriodiction*, *Wigandia*, and *Turricula*, as well as *N. rothrockii*.

Beginning in the 1990s, molecular studies revealed that Boraginaceae was paraphyletic, with hydrophyll genera appearing within the otherwise monophyletic family (Olmstead et al. 1993, Cosner et al. 1994, Ferguson 1998a,b, Albach et al. 2001, Gottschling et al. 2001). In order to maintain Boraginaceae as a monophyletic group, Hydrophyllaceae was reduced to synonymy under Boraginaceae and its genera are collectively designated subfamily Hydrophylloideae Burnett (APG II, 2003).

Placement of Boraginaceae within the angiosperm phylogeny is unclear, and the family is not currently placed in any order (APG III, 2009). Molecular phylogenetic methods place the family in the euasterid I (lamiids) clade *sensu* APG III (2009) with the orders Garryales, Gentianales, Lamiales, and Solanales (Moore et al. 2010). Within the lamiids, Garryales is sister to a polytomy comprising the remaining three orders and Boraginaceae (APG III 2009).

Uses of *Nama*

No members of the genus are economically important, nor have there been any widespread medicinal or dietary uses of *Nama*. However, there are a few reports of small-scale applications by indigenous peoples of North and South America. *Nama undulata* has been documented as a pesticide used in rural areas of the Sierra de Comechinones in the Cordoba province of Argentina (Goleniowski et al. 2006). *Nama hispida* is used to make a lotion to treat spider or tarantula bites by the Navajo and Kayenta tribes of the Sonoran Desert (Moerman, 2009). In her description of *N. linearis*, Nash (1979) noted that the plant is used as an anti-inflammatory and anti-emetic (presumably in the vicinity of Veracruz, Mexico, where the only known population of the species occurs). Very rarely, notes on herbarium labels accompanying *Nama* specimens note skin irritations or contact dermatitis after handling fresh plants; personal experience confirms these anecdotal reports. *Nama* has been targeted at least twice for bioprospecting efforts: extracts of *N. demissa* demonstrated anti-cancer activities in *in vitro* studies (Donaldson and Cates 2004), and a few species have tested positive for the presence of insect growth regulators (Binder 1989).

METHODS

The following diagnostic key to the species of *Nama* was prepared via detailed morphological observations of 394 herbarium specimens, geographic and phenological information from herbarium labels, and field observations. In addition to the specimens housed at LL/TEX, loaned material generously provided by CAS, GH, NY, MO, RSA, and US was examined. Revisionary work on the nine species of the *Nama stenophylla* clade relied on the detailed examination of 125 herbarium specimens as well as distribution, phenology, and ecology data from the labels of an additional 172 specimens and field observations. Chromosome counts were obtained from literature (Table 4.3; Bacon 1974, 1984; Bacon and McDonald 1991; Cave and Constance 1947, 1950, 1959; Diers 1961; Kuzmanov and Nikolova 1977; Tyrl et al 1984; Ward 1983, 1984).

Morphological features were measured using Mitutoyo Digimatic electronic calipers (Mitutoyo America Corporation, Aurura IL) connected to a Dell laptop, with automated data entry to a Microsoft Access database. Width measurements for all relevant plant parts were taken at the widest point. Vestiture across each plant (stems, leaves, sepals, corollas, ovaries, and capsules) was assessed for density and indument type. Density was divided into three subjective categories: scattered/sparse, moderate, and dense. Vestiture was considered to be "sparse" if individual trichomes were spaced very far apart and were generally not overlapping. "Moderate" vestiture was recorded if trichomes occurred more closely together, but the underlying leaf blade was clearly visible through the indumentum. Vesture was categorized as "dense" if trichomes were so closely spaced that it was difficult to observe the underlying leaf blade; "dense" vestiture resulted in challenges to observing whether or not stems, leaves, or calyces possessed glandular trichomes. Indument type was determined by trichome length (long or short), texture (rigid or soft), stature (erect or appressed), and shape (straight or not straight) using Harris and Harris (1994), Hickey and King (2001), and Lawrence (1963; glossary) as guides. Glandular and eglandular trichomes were considered separately, with eglandular trichomes contributing to vestiture descriptions and glandular trichomes assessed simply for presence or absence. In species of *Nama* that posess them, glandular trichomes are diminutive and capitate, producing a short "underlayer" below the non-glandular indument.

Plant height measurements and observations of stature (e.g., erect, decumbent, ascending) were obtained from herbarium labels. In one case (*N. flavescens*), no labels contained height information and the height range reported here was published by Hitchcock (1939).

Leaf shape was determined by comparison with leaf-shape figures in Hickey and King (2001) and Harris and Harris (1994). Harris and Harris's figures (1389c and 1389d; 1994) illustrating the distinction between spatulate and oblanceolate were particularly helpful, with spatulate leaves broadest at the apex and having a rounded tip, and oblanceolate leaves broadest halfway to three-quarters toward the apex and with having an acute tip. Leaf length was measured from the point of attachment to the stem (exclusive of any decurrent portion) to the blade tip. Three mature leaves per plant were measured, with an effort to capture variation in size among leaves within an individual plant. Large basal leaves were not measured because they are typically much larger than stem leaves and would thereby provide a misleading sense of maximum length and width especially because the basal portion of *Nama* plants are often absent from herbarium specimens.

Measurements of sepal length and width, corolla length, corolla tube width, and corolla limb width were made from two dried flowers per specimen with an effort to encompass size variation (Figure 4.1). Corolla lobe widths were measured on either dried or rehydrated flowers, as no difference was observed between the two methods. When possible, one flower (rarely two, if there was uncertainty about an observation) from each herbarium specimen was rehydrated for several minutes in hot water and placed on a small (ca. 4 cm^2) square of acid-free paper for dissection and examination under a 7-30X dissecting microscope. Stamen length was measured from the base of the corolla to the tip of the anther. The portion of the filament that was adnate to the corolla was measured from the base of the corolla to the point where it became free; the free portion was measured from that point to the tip of the anther. Flower color observations were obtained from field observations and herbarium labels. Because corollas of *Nama* species universally fade to light purple or white when dried, the colors of dried corollas were not recorded. Corolla shape was determined from observations of well-preserved (i.e., not folded or wrinkled) dried flowers, using Harris and Harris (1994) as a guide.

A KEY TO THE SPECIES OF *NAMA* (BORAGINACEAE)

<u>Nama</u> L.

Herbaceous to suffruticose ANNUAL OR PERENNIAL HERBS AND SUBSHRUBS, 2—60 cm tall, vestiture ranging from velutinous to strigose, with 0.1—2(2.4) mm trichomes. STEMS terete or winged, prostrate, ascending, or erect, with simple or dichotomous branching. LEAVES sessile or petiolate, linear, lanceolate, elliptic, oblanceolate, obovate, or spatulate (occasionally deltoid or reniform), 7—45(58) mm long, 0.6—30 mm broad, sparsely to moderately velutinous to strigose, glandular trichomes often (though not always) present. INFLORESCENCES single or paired in axils or with 2-10 flowers in lateral or terminal cincinni. PEDICELS absent or up to 15.0 mm long. CALYCES usually divided practically to base, occasionally united up to ½ of calyx length, lobes linear, linear-lanceolate, or spatulate, 2.0—11.6 mm long, ca. 0.5—1.8 mm broad at base, (0.1)0.2—0.8 mm broad at apex, moderately or densely sericious or pilose to hirsute, hispid, or strigose, captitate glandular trichomes often present. COROLLAS white, pink or purple (occasionally red or creamy yellow), tubular-funnelform, salverform, or obconic (campanulate in *Nama californica*), (1.5)3—22 mm long, corolla tube 1.5—10.0 mm broad when corollas are pressed flat and not dissected, corolla limb 1.0—16.0 mm broad, puberulent or pubescent on adaxial (outer) surface (sometimes glabrous), corolla lobes 05—5.0 mm broad at broadest point. STAMENS subequal to unequal in length, shortest stamens 0.7—13.0 mm long, insertion equal or unequal, adnate portion of filaments 0.5—5.5 mm long, often with free winged margins, those wings either squared or rounded at apex or with a distinct apical "tooth," free portion of filaments 0.3—7.5 mm long. STYLES two (2), usually free to base but occasionally fused for up to ¾ of their length, 0.5—8.0(11.0) mm long (including stigma). OVARY 0.4—5.8 mm long, 0.3—4.0 mm broad, apically puberulent to hirtellous for 1/3 to ½ length. FRUITS loculicidally dehiscent capsules 2.0—8.2 mm long, 1.4—4.6 mm broad, glabrous to very sparsely puberulent at apex, styles persistent. SEEDS yellow or brown, ovoid or irregularly-shaped with reticulate, alveolate, or rugulose surfaces, often with large shallow pits, 0.2—1.0 mm long, 4--150 per capsule.

The following key includes the 52 species recognized for this study, as well as four as yet undescribed species (in prep). Inclusion of these four taxa does not meet ICBN standards for valid publication and therefore is not intended to constitute publication. Descriptions leading to the identification of *Nama ehrenbergii* reflect the species description (Brand 1916) rather than firsthand observation. *Nama ehrenbergii* is known only from its type collection (*Ehrenberg* 960, San Sebastian, Mexico, April 1837 [B]), which was apparently housed only at B and lost during WWII. Intensive searching did not uncover any drawings or photographs of the type specimen.

1a. Leaves linear or linear-oblong.

  2a. Leaves succulent (apparent on herbarium sheets by wrinkled/shriveled appearance); free portion of stamen filaments shorter than or approximately equal to adnate portion.

    3a. Calyces glandular, corollas with hirtellous vestiture.

      4a. Herbage (both fresh and dried) clearly yellowish-green………..*N. flavescens*

      4b. Herbage (both fresh and dried) green or grayish-green.

        5a. Adnate portion of stamen filaments possessing a sharp “tooth” at apex.

          6a. Plants growing on limestone substrate; lower portion of stems robustly woody; plants shrubby (branched at base)……....*N. johnstonii*

          6b. Plants growing on gypsum deposits; lower portions of stems usually herbaceous (not woody); plants not shrubby (originating from a single stem)……………………………………*N. stenophylla*

        5b. Adnate portion of stamen filaments squared off or rounded (not tooth-shaped)…………………………………………….….*N. constancei*

    3b. Calyces eglandular; corollas with puberulent to pubescent vestiture.

7a. Plants shrubby, obviously woody at the base; corollas white (sometimes with a pinkish tinge) or yellow or cream-colored; capsules with fewer than 50 seeds.

8a. Plants of the United States (New Mexico and Texas); styles less than 4 mm long; adnate portion of stamen filaments narrowly winged (<1 mm broad)…………………………………...………………*N. carnosa*

8b. Plants of Mexico (Nuevo Leon); styles 4 mm or longer; adnate portion of stamen filaments very broad (>1 mm)………..….*N. hitchcockii*

7b. Plants not woody at the base; corollas bright pink or purple; capsules with more than 50 seeds…………………………………………*N. canescens*

2b. Leaves not succulent; free portion of stamen filaments longer than adnate portion.

9a. Plants prostrate, decumbent, or spreading; calyx vestiture densely whitish-gray, soft, pilose or sericeous; leaf margins revolute (rolled under)…….. ……………………………………………………………...…….*N. demissa*

9b. Plants erect or ascending; calyx vestiture greenish, moderately hirsute-hispid; leaf margins flat (not rolled under).

10a. Stem vestiture of two types on the same plant: sparsely to moderately hirsute or hirsute-hispid and a layer of shorter, finer retrorse hairs……..……. ………………………………………………………...………*N. retrorsa*

10b. Stem vestiture uniformly strigose or appressed-hirsute.

11a. Styles approximately 2 mm long…………...………..……..*N. monclova*

11b. Styles approximately 4 mm long…………………………..…*N. stevensii*

1b. Leaves other than linear or linear-oblong (e.g., elliptic, spatulate, ovate, deltoid).

12a. Leaves opposite (including plants that have alternate leaves at the bases of branches and opposite leaves at branch tips).

13a. Corollas 7-11 mm long.

14a. Styles longer than 4 mm…………………….………………… *N. parvifolia*

14b. Styles shorter than 4 mm…………..…………………. *N. cuatrocienegensis*

13b. Corollas less than 7 mm long.

15a. Plants obviously perennial; branches at base of plants woody; pedicels at least 9 mm long and curving or S-shaped at anthesis……………... ………………………………………….…………..……*N. serpylloides*

15b. Plants annual or weakly perennial; branches at base of plants herbaceous; pedicels less than 5 mm long and straight at anthesis………….... …………………………………………………….…..*N. rzedowskii*

12b. Leaves alternate throughout.

16a. Stems winged.

17a. Styles united for some portion of their length.

18a. Adnate portion of stamen filaments entirely fused to corolla (i.e., free margins or wings are absent); plants of western North America (Oregon, Idaho, California, Nevada, Baja California).

19a. Corollas 7—16 mm long; styles longer than 2 mm……..*N. aretioides*

19b. Corollas 2.5—5 mm long; styles shorter than 2 mm.

20a. Plants with dichotomous branching; corollas 4—5 mm long…….. ……………………………………...……..……*N. parviflora*

20b. Plants with simple branching; corollas less than 4 mm long……... ………………………………………….………...…*N. densa*

18b. Adnate portion of stamen filaments with free-margined scales or wings; plants of SE United States, NE Mexico, Central America, or

Argentina.

21a. Plants prostrate or procumbent; flowers single or in clusters of 2-3; corollas white.

22a. Pedicels filiform; calyx lobes 4—7 mm long, not adhering to capsules; corollas 7—10 mm long……………...………….*N. biflora*

22b. Pedicels stout; calyx lobes 8—11 mm long, adhering to capsules; corollas 5—7 mm long……………....……..*N. jamaicensis*

21b. Plants ascending or erect; flowers in clusters of 4 or more; corollas purple……………………..…………………..…..*N. hintoniora*

17b. Styles free to base.

23a. Leaves and calyces with glandular trichomes; corollas pink or white.

24a. Plants erect or ascending; stems slender; leaves cordate with long petioles; corollas more than 10 mm long………...……..*N. marshii*

24b. Plants spreading or mat-forming; stems more robust; leaves spatulate or oblanceolate and sessile; corollas less than 6 mm long……. …………………………………………...…………..*N. depressa*

23b. Leaves and calyces lacking glandular trichomes; corollas blue or lavender……………………………………...…………*N. bartlettii*

16b. Leaf bases or petioles clasping the stem.

25a. Styles united for some portion of their length.

26a. Calyx divided to the base, not fused to ovary or capsule.

27a. Stems, leaves, and calyces with coarse hirsute or hispid vestiture; flowers solitary or in pairs.

28a. Branches erect or ascending; leaves obovate; capsules with more than 40 seeds……………………………… *N. ehrenbergii*

28b. Branches prostrate or spreading; leaves spatulate or oblanceolate; capsules with less than 40 seeds……..….*N. aretioides*

27b. Stems, leaves, and calyces with soft canescent or pilose vestiture; inflorescences with more than 2 flowers…...……...*N. palmeri*

26b. Calyx united approximately halfway, fused to ovary and to capsule…… ……………………………………………….…...……….*N. stenocarpa*

25b. Styles free to base.

29a. Leaves and/or sepals with glandular trichomes.

30a. Free portion of stamen filaments longer than adnate portion.

31a. Plants of the Hawaiian Islands………..………….*N. sandwicense*

31b. Plants of North, Central, or South America.

32a. Stem vestiture hirsute or hispid.

33a. Flowers borne in inflorescences of 3 or more flowers.

34a. Plants erect or ascending herbs or subshrubs; leaf vestiture sparsely to moderately pubescent, hirsute, or occasionally approaching strigose.

35a. Seeds yellow…………………………...…*N. turneri*

35b. Seeds brown.

36a. Perennials; capsules with 12 or fewer seeds

37a. Leaves broad: ovate, oblong-ovate, or elliptic; styles 4—5 mm long……….….*N. hirsuta*

37b. Leaves narrow: oblanceolate or narrowly elliptic; styles ca. 2 mm long……….….*N. baconii*

36b. Annuals; capsules with 10—40 seeds.

38a. Corollas 8—10 mm long; styles 2—2.5 mm long………………………….……….*N. pringlei*

38b. Corollas 4—6 mm long; styles 1—2 mm long

39a. Leaves narrowly elliptic or oblanceolate, less than 5 mm broad at widest point, narrowing to base, either sessile or with petioles less than 2 mm long…....*N. dichotoma*

39b. Leaves ovate to oblong-ovate, up to 16 mm broad at widest point, with petioles longer than 2 mm………………………..……..……………...*N. pueblensis* or *N. "whalenii"*

34b. Plants forming small, dense mounds, almost cushion-like in appearance; leaf vestiture densely villous, giving leaf surfaces velvety texture………......……*N. origanifolia*

33b. Flowers borne singly or in pairs.

40a. Calyx lobes hardening in fruit, adhering to capsule……..……………………………………….….….*N. jamaicensis*

40b. Calyx lobes chartaceous in fruit, not adhering to……….. capsule…………………………....…………*N. prostrata*

32b. Stem vestiture a combination of hirsute or hirtellous and pilose, velutinous, or sericeous.

41a. Leaves elliptic spatulate, oblong, or oblanceolate………..…………………………………………..……….*N. quiexobrana*

41b. Leaves reniform or cordate……..……………*N. propinqua*

30b. Free portion of stamen filaments equal to or shorter than adnate portion.

42a. Seeds yellow…………………………………………*N. hispida*

42b. Seeds brown.

43a. Inflorescences with 1-4 flowers.

44a. Calyx lobes linear-lanceolate, pilose or sericeous; free portion of stamen filaments shorter than adnate portion.

45a. Leaves borne on pedicels, moderately to densely sericeous or sericeous-pilose, with plane (flat) margins; corollas 7—12 (14) mm long…..………….………*N. havardii*

45b. Leaves sessile, sparsely hirsute, with revolute (rolled under) margins; corollas 10—16.5 mm long……….
……………………………………….…….*N. "jimulco"*

44b. Calyx lobes very narrowly linear, almost threadlike, hirsute; free portion of stamen filaments approximately equal to adnate portion……..……………...………..*N. linearis*

43b. Inflorescences with 3—10 flowers.

46a. Leaves with distinct petioles; flowers borne on pedicels.

47a. Leaves ovate, broadly elliptic, or nearly deltoid, with flat margins; corollas tubular-funnelform, 7—9 mm long; capsules with more than 100 seeds…...*N. rotundifolia*

47b. Leaves spatulate with revolute margins; corollas salverform, 3—4 mm long; capsules with fewer than 80 seeds……………………….……………*N. torynophylla*

46b. Leaves and flowers sessile……...……………..*N. xylopoda*

29b. Leaves and sepals lacking glandular trichomes.

48a. Plants with dichotomous branching (forked); plants of western North America (California, Idaho, Nevada).

49a. Corollas short-campanulate, approximately 2 mm long; capsules with 4 or fewer seeds…………………..……*N. californica*

49b. Corollas tubular or tubular-campanulate, 4—13 mm long; capsules with 10—40 seeds.

50a. Leaves rhombic to ovate, less than 6 mm long…..…..*N. pusilla*

50b. Leaves spatulate, 10—25 mm long………..………*N. demissa*

48b. Plants with simple branching (not forked); plants of southern United States, West Indies, central-eastern Mexico, and Central and South America.

50a. Stems winged; calyx adhering to capsule……….…*N. jamaicensis*

50b. Stems not winged; calyx not adhering to capsule.

51a. Plants erect or ascending; corollas salverform, less than 5 mm long……………………………………………*N. segetalis*

51b. Plants creeping or procumbent; corollas funnelform, 10—15 mm long.

52a. Leaves ovate-rotund to obovate,; free margins of adnate portion of stamen filaments with squared or rounded apex…… ………………………………..………..…………*N. prostrata*

52b. Leaves ovate-lanceolate to elliptic-lanceolate; free margins of adnate portion of stamen filaments with distinct tooth at apex………………….…..………*N. orizabensis*

A REVISION OF THE *NAMA STENOPHYLLA* CLADE

The *Nama stenophylla* clade is a group of nine species endemic to gypsum and limestone deposits in the Chihuahuan Desert Region and adjacent arid zones of the southwestern United States and Mexico (Figure 4.2). Three species – *N. canescens, N. carnosa,* and *N. stenophylla* – are obligate gypsophiles; four species – *N. constancei, N. flavescens, N. havardii,* and *N. hitchcockii* – are facultative gypsophiles with varying degrees of fidelity to gypsum; one species – *N. johnstonii* – is endemic to limestone hillsides and cliffs; and the substrate preference of one species, *Nama "Jimulco,"* is thus far unknown. Morphologically, most of the species in this group are radically different from the remainder of *Nama*. Their robust, erect habit and linear, nearly terete leaves distinguishes them from species outside the clade. Two species, *Nama havardii* and *N. "jimulco"* are exceptions that bear ovate or lanceolate leaves, respectively. Table 4.4 describes the most-easily observed characters that may be used to discriminate between species of the *Nama stenophylla* clade.

Six additional gypsophiles are unrelated to the *Nama stenophylla* clade but occur in the Chihuahuan Desert Region and adjacent arid zones: *N. palmeri*, *N. serpylloides*, *N. hispida*, *N. turneri*, *N. "monclova,"* and *N. stevensii*. Of these six, *N. "monclova"* and *N. stevensii* have converged on the linear-leaved form but are distinguished from the species of this group by their shorter, spreading (rather than erect) stature and yellow (vs. brown) seeds.

1. *Nama canescens* C.L. Hitchc., Am. J. Bot 26(5): 345. 1939. TYPE: MEXICO. San Luis Potosi. 38 miles south of Matehuala on disturbed soil of gypsum plain, 10-11 Sep 1938, *I.M. Johnston 7510* (holotype: GH!).

Low mounding, decumbent to ascending, robust ANNUAL OR BIENNIAL HERBS branching from base and above, 10--20cm tall, hispid, with 0.3--1.8 mm eglandular trichomes. STEMS robust, hirsute-hispid with a dense pubescent underlayer. LEAVES sessile, linear, 6.4--29.3 mm long, 0.7--1.5 mm broad, moderately to dense hispid to strigose-hispid, glandular trichomes absent. INFLORESCENCES with 1-4 subsessile flowers in axils and terminal cymes. PEDICELS 0.6--1.4 mm long. CALYCES divided to base. SEPAL LOBES linear, 2.7--6.4 mm long, ca. 1.2 mm broad at base, ca. 0.7 mm broad at apex, hispid; glandular trichomes present. COROLLAS pink, purple, or occasionally rose-red, funnelform, sometimes approaching salverform, 5.1--8.4 mm long, corolla tube 1.6--2.8 mm broad when corollas are pressed flat and not dissected, corolla limb 3.5--6.8 mm broad, pubescent on adaxial (outer) surface; corolla lobes 1.3--2.5 mm broad at widest point. STAMENS unequal in length, shortest stamens 2.0--3.5 mm long, longest stamens 2.6--4.4 mm long, insertion unequal; adnate portion of filaments 0.6--2.4 mm long, winged; free portion of filaments 0.8--2.2 mm long. STYLE 1.5--2.2 mm long (including stigma). OVARY 0.9--2.5 mm long, 0.6--1.4 mm broad, pubescent or hispidulous at apex. FRUITS puberulent at apex, 3.1--5.2 mm long, 1.3--2.5 mm broad. FRUITING PEDICELS up to 2.7 mm long. SEEDS brown, reticulate, 0.5--0.6 mm long, 0.3--0.4 mm broad, 38--114 per capsule.

Phenology: Flowering and fruiting from June to October.

Distribution: Restricted to gypsum outcrops; widespread along the eastern edge of the Chihuahuan Desert Region in Mexico, ranging from approximately 100 km northwest of Monterrey (Nuevo Leon) south to Matehuala (San Luis Potosi; Figure 4.3).

Additional specimens examined: **MEXICO. Nuevo Leon.** Aramberri, San Francisco de Leos Gypsum hillside, 24° 19' N 99° 43' 13" W, 17 Oct 1992, *Hinton 22571* (LL, TEX); Doctor Arroyo, Cerro Pe±a Nevada lado NW, gypsum outcrops on NW slope, 23° 46' 45" N 99° 52' 12" W, Jul 1977, *Wells 515* (LL); Galeana, El Aguililla, llano at edge of cultivated field, 24° 58' 11" N 100° 33' 40" W, 23 Jul 2000, *Hinton 27650* (TEX); Galeana, 15.2 mi south of San Roberto , jct of Hwy 60 and Hwy 57, south of Saltillo on Hwy to Matehuala, gypsum flats, Gymnosperma - *Frankinia* - gramineae, 24° 30' 13" N 100° 17' 19" W, 22 Aug 1984, *Lavin 4758* (LL, TEX); Galeana, S.A. de Texas. Gypsum hillside, 24° 18' 41" N 100° 11' 16" W, 19 Aug 1992, *Hinton 22312* (LL, TEX); Galeana, 12.6 mi east of Entronque San Roberto Junction (toward Linares) . Juniper pine zone in "pure" gyp soils, 24° 41' 35" N 100° 6' 58" W, 26 Sep 1970, *Turner 6229* (TEX); General Zaragoza, entre General Zaragoza y El Salitre, gypsum hillside, 23° 58' 17" N 99° 48' 33" W, 26 Aug 1992, *Hinton 22346* (TEX); On open gypsum plains ca. 35 air miles SE of Saltillo, 0.5 miles N of Navidad, or 4.2 miles N of San Rafael along Hwy 57, a prairie dog town with *Dicranocarpus, Calylophus, Nama, Sartwellia mexicana, Bouteloua chasei* etc., 26 Jun 2001, *Henrickson 22657 5* (LL, TEX); 13 Jul 1953, *Manning 53279* (GH); **San Luis Potosi.** Just W of Hwy 57 on rd to Cedral, gypsum flat, 23° 41' 49" N 100° 37' 5" W, 5 Sep 1971, *Bacon 1123* (LL, TEX); 36 mi S of Matehuala at village of Valljais (Vallejo?), 26 Sep 1970, *Turner 6212* (LL, TEX); 3-5 mi N of Matehuala towards Cedral in low gypsum flats, with *Prosopis, Larrea, Lycium, Microrhamnus, Flaveria* grasses etc, 23° 42' N 100° 39', 7 Sep 1971, *Henrickson 6548* (TEX); 11-12 Sep 1938, *Johnston 7584* (GH). **Nuevo Leon.** Ca. 18 mi E of San Roberto Junction along highway 60, 0.5 mi N of intersection to Dr. Arroyo. East side of road in gypsum flat very nearly at 24° 44' N lat, 100° 02' long. *BL and GL Turner 15009* (TEX); 2 Nov 1980.

This widespread obligate gypsophile is most closely related to *Nama hitchcockii* (as discussed in Chapter 3), a narrowly-distributed obligate gypsophile whose geographic distribution is entirely within the range of *N. canescens*. (Figure 4.3, 4.4). The two species are easily distinguished from each other based on woodiness, flower color, and style length: *N. canescens*, while robust, is not woody, has pink or purple corollas, and styles that are ca. 2mm long. In contrast, *N. hitchcockii* is noticeably woody at the base, bears white or cream-colored corollas, and has styles that are twice as long as in *N. canescens*. Furthermore, although the longest leaves measured on *N. canescens* plants fell within the length variation observed in *N. hitchcockii*, the leaves of the latter species are on average almost twice as long as the leaves of *N. canescens*.

2. *Nama carnosa* (Wooton) C.L. Hitchc., Am. J. Bot 26(5): 345. 1939.

Conanthus carnosus Wooton, Bull. Torr. Bot. Club 25:262. 1898. TYPE: USA. New Mexico. Dona Ana Co., White Sands, 17 Jul 1897, *E.O. Wooton 164* (Lectotype here designated: RSA-POM! Isolectotypes: B, US!, MO!).
Andropus carnosus (Wooton) Brand, Pflanzenr. 4:251. 163. 1913.

Nama stenophyllum var. *egenum* J.F. MacBr., Contr. Gray Herb. 49:44. 1917. TYPE: USA. Texas. Bluffs of Delaware Creek, Guadalupe Mts., 1882, *V. Havard 15* (holotype: GH!)

Erect, suffruticose, PERENNIAL robust HERB OR SUBSHRUB branching mostly from base and above, 18--30cm tall, strigose or strigose-hirsute, with 0.1--1.5 mm eglandular trichomes. STEMS robust, hirsute with a dense hirtellous or puberulent underlayer. LEAVES sessile, linear, 7.9--48.2 mm long, 0.5--1.8 mm broad, moderately strigose to strigose-hirusute, glandular trichomes absent or sparselyly mealy-glandular. INFLORESCENCES with 1-7 subsessile to pedicellate flowers in terminal cymes. PEDICELS 0.5--1.1 mm long. CALYCES divided to base. SEPAL LOBES linear or linear-lanceolate, 4.4--9.8 mm long, ca. 0.9 mm broad at base, ca. 0.6 mm broad at apex, strigose to strigose-hirsute; glandular trichomes absent or occasionally present, sparsely mealy-glandular. COROLLAS white, tubular, 6.9--10.1 mm long, corolla tube 1.6--3.7 mm broad when corollas are pressed flat and not dissected, corolla limb 1.6--3.5 mm broad, fuzzy-pubescent top half or densely pubescent on lobes almost to base on adaxial (outer) surface; corolla lobes 0.7--1.4 mm broad at widest point. STAMENS unequal in length, shortest stamens 3.7--6.3 mm long, longest stamens 4.9--7.4 mm long, insertion approx equal or unequal; adnate portion of filaments 2.2--5.5 mm long, winged; free portion of filaments 1.3--2.2 mm long. STYLE 2.2--3.9 mm long (including stigma). OVARY 1.2--3.2 mm long, 0.7--1.7 mm broad, densely white pubescent top half. FRUITS hirtellous (1 sample hirsute), 2.4--3.7 mm long, 1.3--1.7 mm broad. FRUITING PEDICELS up to 1.5 mm long. SEEDS brown, alveolate and granular or reticulate, pitted, 0.4--0.5 mm long, 0.3--0.4 mm broad, 20--51 per capsule.

Phenology: Flowering and fruiting from May to August.

Distribution: Restricted to gypsum dunes and gypsum flats from central New Mexico to west Texas and south to Chihuahua (Figure 4.5).

Additional specimens examined: **USA. New Mexico.** Eddy Co., 6 Aug 1941, *Shreve 10250* (GH); Eddy Co., 30 May 1993, *Turner 93-9* (LL/TEX); 21 Aug 1941, *Tharp 19* (GH); 24 Jun 1970, *Powell 1924* (LL, TEX); Rocky, gypsiferous slopes, Bottomless Lakes State Park (Roswell), 18 Aug 1967, *Secor 63* (LL/TEX); **Texas.** Culberson Co., 23.4 miles west of Reeves Co. line along highway 652. Occurring on gypsum knolls, 31^o 54' N 104^o 24', 1 Aug 2000, *Turner 20-450* (TEX); Culberson Co., powdered gypsum ridges, 12 Jun 1943, *Waterfall 4475* (GH); Hudspeth Co., southeast base of Malone Mts on gypsum flat, 5 Jul 1958, *Correll 19297* (LL).

Nama carnosa is the northernmost species in the *Nama stenophylla* clade, ranging from central New Mexico to west Texas as far south as northern Chihuahua, Mexico. This species seems to prefer gypsum dunes like those found at White Sands National Monument in New Mexico, though it has occasionally been collected from gypsum flats. It forms small, rounded shrubs that are very woody throughout; Hitchcock (1939) suggested that a paucity of herbarium specimens was a result of its "dried-out" appearance in the field leading to collectors passing it by.

3. *Nama constancei* J.D. Bacon, SIDA Contr. Bot. 9(2): 100. 1981. TYPE: MEXICO. Coahuila. ca 62 (air) mi. WSW of Cuatro Cienegas, in gypsum outcropping on northside of Sierra de los Organos, ca 5 mi. SW of Cuesta del Gallo, near 26^o 44' N lat., 108^o 03' W long., 4400 ft, 8 Aug 1973, *J. Henrickson 12113* (Holotype: TEX!).

Erect, suffruticose, PERENNIAL SUBSHRUB branching mostly from base and above, 21--21cm tall, strigose to hirsute-hispid, with 0.1--1.2 mm eglandular trichomes. STEMS robust, strigose or hirsute with a puberulent underlayer. LEAVES sessile, linear and terete, 13.9--48.3 mm long, 0.8--2.2 mm broad, sparsely to moderately strigose to strigose-hirusute, glandular trichomes present, occasionally very scarce. INFLORESCENCES with 1-3 subsessile to pedicellate flowers in axils or few-flowered terminal cymes. PEDICELS 1.9--6.7 mm long. CALYCES divided to base. SEPAL LOBES linear, 6.9--12.7 mm long, ca. 1.5 mm broad at base, ca. 0.8 mm broad at apex, strigose to hirsute-hispid; glandular trichomes usually present but sometimes absent. COROLLAS pale pink or white, tubular to tubular-salverform, 10.0--13.8 mm long, corolla tube 2.0--3.9 mm broad when corollas are pressed flat and not dissected, corolla limb 4.1--7.0 mm broad, hirtellous on lobes on adaxial (outer) surface; corolla lobes 1.5--3.3 mm broad at widest point. STAMENS unequal in length, shortest stamens 6.0--8.2 mm long, longest stamens 9.1--11.4 mm long, insertion unequal; adnate portion of filaments 3.2--8.9 mm long, winged; free portion of filaments 1.5--3.7 mm long. STYLE 5.7--7.9 mm long (including stigma). OVARY 1.3--2.3 mm long, 0.8--1.2 mm broad, pubescent to hirtellous at top half. FRUITS puberulent at apex, 3.1--4.2 mm long, 1.7--2.6 mm broad. FRUITING PEDICELS up to 4.5 mm long. SEEDS brown, shallowly reticulate/alveolate, 0.4--0.4 mm long, 0.2--0.3 mm broad, number per capsule not counted.

Phenology: Flowering and fruiting from August to October.

Distribution: Gypsum outcrops on steep slopes and canyon walls and occasionally in limestone arroyos (often mentioned as being “near” gypsum) between the Bolson de Cuatrocienegas and Mapimi, west of Monclova and north of Torreon, Coahuila (Figure 4.6).

Additional specimens examined: **MEXICO. Coahuila.** Cuatrocienegas, 72 (air) mi SW of Cuatrocienegas de Carranzaon on E side of Sierra de las Delicias around spring 1.5 mi SW of Las Delicias, with *Fouquieria shrevei, Hedyotis, Agave, Dasylirion, Mortonia, Hechtia, Petalonyx, Selaginella* etc., 26° 12' N 102° 50' 27" W W, 12 Aug 1973, *Henrickson 12248* (LL, TEX); Ocampo, ca 31. 5 rd mi S of Laguna del Rey (Quimicas del Rey) on the paved rd S to San Pedro de las Colonias; in an area of steep gypsum on E side of roadway, these slopes close to Hwy but others extend on for miles; with *Haploestes Grusonia Nama Euphorbi* etc., 26° 42' N 103° 10' W, 25 Sep 1998, *Henrickson 20530 3* (LL, TEX); Ca 32 (air) mi NE of San Pedro, 1 mi SW of Las Delicias at spring on limestone cliffs (possibly on gypsum); with *Celti,s Dasylirion, Acacia, Larrea, Buddleja, Acacia berlandieri* etc, 26° 14' N 102° 49' W, 3560 ft, 27 Aug 1971, *Henrickson 6036* (LL, TEX); S part of Sa de Los Organos approach 9.5 Km E of Puerto del Gallo then by foot S into large canyon Mostly izotal (higher: chaparrales); local md on gyp. *Dasylirion Agave lech. A. asperr. Leucophyllum Vig. sten. Acacia roen*., 26° 43' 30" N 103° 1' W, 8 Aug 1973, *Johnston 12112* (LL, TEX); Ca 62 (air) mi WSW of Cuatro Cienegas in long winding limestone canyon in N side of the Sa de Organos on steep lateral canyon walls, probably gypseous; with *Quercus, Acacia berlandieri, Agave, Dasylirion, Leucophyllum Echinopteris* etc., 26° 41' N 103° 3' W, 8 Aug 1973, *Henrickson 12157* (*1157?*) (LL, TEX); Ca. 18 (air) mi NE of Tlahualilo in Sa de Tlahualilo ca 9 (air) mi NW of Los Charcos de Risa in broad limestone canyon-arroyo E of peak, sides of canyon with gypsum; with *Acacia fouquieria Yucca Cordia Agave Coldenia Opuntia* etc., 26° 17' N 103° 14' W, 30 Sep 1973, *Henrickson 13714* (LL, TEX); Ca. 75 air mi SW of Cuatro Cienegas near N end of Puerto de Ventanillas in S Sa Las Delicias at new Strontium mine in Sa La Caldelaria E of Hwy Area with many exposed steep gypsum slopes among limestone with *Fouquieria shrevei Agave lech.*

Acacia neovernicosa Dasylirion Grusonia Machaeranthera Euphorbia Neolloydia etc, 26° 5' N 102° 42' W, 5 Oct 1997, *Henrickson 22198* (LL, TEX); +/- 2 miles SW of town of Los Delicias above and around the spring (Agua Grande) that flows from the Sierra de Delicias above the town. Limestone slopes, mixed with gypsum. Area *with Varilla, Acacia, Hechtia, Tiquilia greggii, Croton, Tidestromia, Jatropha dioica, Ocotillo, Leucophyllum, Agave lech. Agave striata* etc., 26° 48' N 102° 12' W, 16 Oct 2002, *Henrickson 23112 7* (LL, TEX); 25 Sep 1942, *Stewart 2752* (GH); 12 Km NNE of Las Margaritas on the E-most ridge of the Sa de las Margaritas; Crasirosulifolios espinosos y matorral des. *Agave lech. Hechtia Acacia neover. Bouteloua sp. Dasylirion*, 26° 33' 30" N 102° 51' 30" W, 24 Sep 1972, *Chiang C 9508b* (LL, TEX). Ca. 32 (air) miles NE of Tlahualilo, in the NW portion of the Sierra de las Delicias, in the first canyon S of the Puerto de las Sardines; on limeston, infreq. perennial in upper canyon near gypsum outcropping; with Agave lechugilla, Yucca thompsoniana, Agave falcate, Dasylirion, Acacia, Mimosa, Larrea, Opuntia, etc. 26° 22' N, 103° 06' W, 4400 ft, 9 Aug 1973, *Henrickson 12211* (TEX).

Nama constancei is a woody subshrub that is much branched at the base. It has quite long leaves like *N. hitchcockii* but occurs farther north and at lower elevation. The pink flowers of this species are notable for having stamens that are nearly as long as the corollas, or in some cases, slightly exserted; the adnate portions of the wings are very narrow, but almost universally have a very prominent "tooth" projecting from the apices of the wings. The free portions of the filaments are stout rather than filiform in the other species of the group. Like *N. flavescens*, the leaves of this species are often yellowish-green rather than grayish-green as in most of the other *Nama stenophyllum* clade species. From the collection records, *N. constancei* appears to be nearly obligately gypsophilic.

Most of the collections specify gypsum as the substrate, however, a few (*Henrickson 6036*, *Henrickson 12157* (*1157?*), *Henrickson 13714*, *Henrickson 23112 7*) indicate either limestone mixed with gypsum or limestone and gypsum in close proximity, leading to uncertainty as to on which substrate exactly the plants were collected and whether populations of this species may even prefer the interface between gypsum and limestone substrates. For this reason, we hesitate to designate *N. constancei* an obligate gypsophile at this time. More extensive exploration of both gypsum and calcareous habitats within the geographic range of the species will provide valuable information regarding the substrate preferences of this species.

4. *Nama flavescens* Brandegee, Zoe 5: 254. 1908. TYPE: MEXICO. Coahuila. near Parras, gravelly soil, Feb 1906, *C.A. Purpus 1875* (Lectotype here designated:US! Isolectotypes GH! UC, MO!).

Nama stenophyllum var. *flavescens* (Brandegee) C.L. Hitchc. Am. J. Bot. 20(6):425.

Erect, suffruticose, PERENNIAL SUBSHRUB branching mostly from base and above, 12--12cm tall, hirsute or hispid, with 0.1--1.6 mm eglandular trichomes. STEMS robust, sparsely hirsute or hirsute-hispid. LEAVES sessile (1 petiolate), linear, 4.5--32.7 mm long, 0.5--2.2 mm broad, sparsely to moderately hirsute to hispid, glandular trichomes present. INFLORESCENCES with 2-10 pedicel flowers in terminal cymes (occasionally in axils). PEDICELS 1.4--3.8 mm long. CALYCES divided to base. SEPAL LOBES linear, 3.6--7.1 mm long, ca. 1.0 mm broad at base, ca. 0.7 mm broad at apex, hirsute to hirsute-hispid; glandular trichomes present. COROLLAS pink or purple, salverform, 6.0--10.2 mm long, corolla tube 1.5--3.0 mm broad when corollas are pressed flat and not dissected, corolla limb 3.2--7.6 mm broad, puberulent on adaxial (outer) surface; corolla lobes 1.5--3.3 mm broad at widest point. STAMENS unequal in length, shortest stamens 2.4--4.6 mm long, longest stamens 3.8--6.5 mm long, insertion unequal; adnate portion of filaments 1.2--4.3 mm long, winged; free portion of filaments 1.4--2.6 mm long. STYLE 2.6--3.1 mm long (including stigma). OVARY 0.8--2.0 mm long, 0.5--1.0 mm broad, hirtellous top 1/2. FRUITS glabrous to v sparsely puberulent at apex, 2.3--3.5 mm long, 1.4--1.9 mm broad. FRUITING PEDICELS up to 4.8 mm long. SEEDS brown, reticulate, 0.4--0.7 mm long, 0.3--0.6 mm broad, 13--62 per capsule.

Phenology: Flowering and fruiting from February to November.

Distribution: Gypsum deposits or limestone or shale slopes in the vicinity of Saltillo, Coahuila and into Zacatecas (Figure 4.6).

Additional specimens examined: **MEXICO. Coahuila.** 2.5 mi SW of Parras de La Fuente (Parras), over-grazed limestone foothills, alt. ca. 6000 ft, 7 Oct 1972, *Gentry 23103* (TEX); Sa de Parras N slope and top approached from Ejido Cerro Colorado, ca. 10 km W of Parras de La Fuente, steep limestone slopes in places somewhat mineralized (gyp near base) calcareous gravel, etc., Crasirosulifolios espinosos (higher: chaparral). *Agave lech. Dasylirion Yucca carnerosana* (higher: *Quercus Fraxinus* etc.), 25^{o} 26’ N 102^{o} 16’ W, 4 Nov 1972, *Chiang 10081* (LL, TEX); 25 Aug 1948, *Kenoyer 3218* (GH); 5 Sep 1940, *Shreve 9864* (GH); **Zacatecas.** Near and at Sa de Yeso almost due W of La Presa de Los Angeles Matorral desertico inerme. *Larrea tridentata, Leucophyllum Acacia neovernicosa*, 25^{o} 4’ N 102^{o} 7’ W, 29 Mar 1973, *Johnston 10483* (LL, TEX); SE of Cedros Matorral desertico con espinas laterales. *Ziziphus lloydii, Prosopis glandulosa,* *Larrea*, 24° 40' 20" N 101° 45' 20" W, 1 Jul 1973, *Johnston 11543A* (LL, TEX); Oct 1907, *Lloyd 143* (GH); 1 km SE of San Juan de los Cedros, on road to Mazapil, gently sloping hillside and fan of whitish calcareous rock, with *Larrea, Flourensia, Celtis pallida, Mimosa* spp., *Dasylirion* , 24° 40' N 101° 46' W, 17 Jun 1972, *Chiang 7926* (LL, TEX); **Unknown state.** Feb to Oct 1880, Palmer *d62* (?) (GH); 14 Nov 2002, *Henrickson 23231* (LL, TEX);

Nama flavescens is a facultative gypsophile that is frequently collected from limestone outcrops; it appears not to prefer gypsum per se but rather to tolerate it. Both in the field and on herbarium specimens collected over half a century ago, this species' yellow-green stem and leaf color is striking and easily distinguishes it from the other linear-leaved species of the *Nama stenophylla* clade. *Nama flavescens* is also woodier at the base than its close relatives, and the leaves, stems, and calyces of this species are conspicuously mealy or glandular.

5. *Nama havardii* A. Gray, Proc. Am. Acad. 20: 309. 1885. TYPE: USA. Texas. Western borders of Texas, on alkaline banks of Tornillo Creek, Aug 1883, *V. Havard 95 ½* (Lectotype here designated: GH!; Isolectotype: US!).

Conanthus havardii (A. Gray) A. Heller, Cat. N. Amer. Pl. 6. 1898.

Nama stewartii I.M. Johnst., J. Arnold Arbor. 22: 114. 1941. TYPE: MEXICO. Coahuila. Sierra de las Cruces, gypsum flats and cliffs at south base of Picacho de San Jose, 29 Aug 1940, *I.M. Johnston & C.H. Muller 814* (Holotype: GH!).

Erect, robust, PERENNIAL HERB branching mostly from base and above, 40--40cm tall, sericeous or pilose, with 0.2--1.1 mm eglandular trichomes. STEMS robust, velutinous to sericeous-pilose. LEAVES petiolate, elliptic, oblong-elliptic, oblong-ovate, oblong-obovate, elliptic-oblanceolate, oblanceolate, elliptic-ovate, 7.0--57.0 mm long, 1.4--14.4 mm broad, moderately to dense sericeous, villous, or sericeous-pilose, glandular trichomes present, occasionally very scarse. INFLORESCENCES with 2-10 pedicel flowers in terminal and lateral cymes. PEDICELS 0.6--5.4 mm long. CALYCES divided to base. SEPAL LOBES linear or linear-lanceolate to narrowly spatulate (linear in fl, toward spatulate in fr), 4.6--8.1 mm long, ca. 1.1 mm broad at base, ca. 1.1 mm broad at apex, pilose or sericeous; glandular trichomes present. COROLLAS pink or white, funnelform to salverform, 6.8--13.9 mm long, corolla tube 1.9--4.6 mm broad when corollas are pressed flat and not dissected, corolla limb 3.7--10.0 mm broad, sparsely hirtellous or pubescent on adaxial (outer) surface; corolla lobes 1.7--4.2 mm broad at widest point. STAMENS subequal to unequal in length, shortest stamens 3.9--6.2 mm long, longest stamens 4.7--7.4 mm long, insertion unequal; adnate portion of filaments 1.9--5.0 mm long, winged; free portion of filaments 1.3--3.4 mm long. STYLE 3.0--4.7 mm long (including stigma). OVARY 1.2--2.9 mm long, 0.6--1.2 mm broad, sericeous top 1/2. FRUITS pubescent at apex, 3.1--5.6 mm long, 1.4--3.4 mm broad. FRUITING PEDICELS up to 4.1 mm long. SEEDS brown, pitted with minute ridges, 0.5--0.7 mm long, 0.3--0.6 mm broad, 14--65 per capsule.

Phenology: Flowering and fruiting from February to October.

Distribution: Gypsum deposits, sandy arroyos, and calcareous soils. Widespread across west Texas and northern Chihuahua and Coahila states (Figure 4.8).

Additional specimens examined: **MEXICO**. **Chihuahua.** Ca. 9 Km W of Ojinaga, on the Hwy to Chihuahua City, 104° 28' 0"N 29° 34' 40" W, 20 Oct 1972, Chiang C. et al 9721 (LL). **Coahuila.** 13 Aug 1940, *Johnston 228* (G, LL/TEX); 27 Oct 1940, *Stewart 315* (GH); 23 Jun 1941, *Stewart 598* (LL, TEX). **USA. Texas.** Brewster Co., Black Gap Wildlife Management Area 57 miles south of Marathon. occasional in Creosote Bush, *Powell 1180* (LL); Brewster Co., Terlingua area. Altitude 3000 feet. Infrequent, along arroyos, 10 Aug 1956, *Warnock 13983* (LL, TEX); Brewster Co., Near Terlingua in bed of creek, 14 Sep 1947, *Lundell 14764* (LL); Brewster Co., on Terlingua Flats near Study Butte, Big Bend National Park, 22 Jul 1957, *Correll 18364* (LL, TEX); Brewster Co., 2 1/4 m. NE of Agua Fria Springs, 13 Apr 1936, Cory 18602 (GH; holotype of *N. havardii* var. *album*); Brewster Co., ca. 65 mi. S of Alpine, gyp hills along roadside, 2 Jul 1970, *Powell 1981*(TEX); Brewster Co., on hills near bridge over lower Tornillo Creek, Big Bend National Park, 17 Apr 1961, *Correll 23612* (LL, TEX); Brewster Co., Hot Springs, 31 Mar 1944, *Cory 44010* (LL, TEX); Brewster Co., near Terlingua, Texas in sandy washes, 2 Apr 1942, *Nelson 5044* (G, LL/TEX); Brewster Co., 71 mi. south of Alpine. Calcareous soils, 29^{o} 28' N 103^{o} 34', 8 Mar 1999, *Turner 99-12* (TEX); Brewster Co., along Tornillo Creek at Hot Springs, Chisos Mountains area, 14 Feb 1937, *Warnock s.n.* (LL, TEX); Presidio, road cut along Camino del Rio, ca. 5 miles south of Redford in loose, rocky, igneous soil, 20 Mar 1966, *Powell 1397* (LL, TEX). Brewster Co., Rt. 118 right outside the entrance to Big Bend National Park in rocky sandy loam, 29^{o} 16' 19" N 103^{o} 28' 8", 9 Mar 2001, *Simpson 9-III-01-4* (LL, TEX); Val Verde Co., ca. 3.2 mi. W of Langtry on rocky limestone soil, 25 Aug 2004, *Turner 24-424* (LL, TEX); Terrell Co., San Francisco Canyon mouth and lowest part of Isinglass Canyon very near the Brewster County line, altitude 475m, in bouldery canyon-bed in limestone plateau, calcareous gravelly soil, with *Acacia berlandieri, Cirsium, Acacia rigidula, Celtis pallida*, 29° 53' 30" N 102° 20' 0", 11 Apr 1973, *Johnston 10626C* (LL, TEX);

Nama havardii is unusual among the species of the *Nama stenophylla* clade because it bears broad, flat leaves rather than the linear, terete leaves that are characteristic of almost all other species in the group. The new species, *N. "jimulco,"* has leaves that are intermediate in width between *N. havardii* and the rest of the lineage, but they are much longer and narrower than those of *N. havardii*.

Johnston (1941) described *Nama stewartii*, considering it a separate entity from *N. havardii* based on its somewhat smaller stature, smaller floral structures (corolla, style, filaments), softer pubescence, and smaller leaves. Plants that Johnston identified as *N. stewartii* were collected from pure gypsum substrates in the Sierra de las Cruces in Coahuila, east of the previously-identified range of *N. havardii*. Close examination of specimens determined by Johnston himself to be *N. stewartii* revealed that character variation within those specimens falls within the range of variation observed within *N. havardii*. While there is a suggestion of some genetic diversification between eastern and western populations due perhaps to geographic and habitat isolation, I think the slight morphological differences observed by Johnston may be attributed to environmental differences (growing on gypsum vs. not) rather than genetic differentiation on an order meriting species recognition.

6. *Nama hitchcockii* J.D. Bacon, SIDA Contr. Bot. 9(2): 99. 1981. TYPE: MEXICO. Nuevo Leon. gypsum flats and ravines in open pinelands, about 3 mi S of Galeana, 20 Jul 1958, *D.S. Correll & I.M. Johnston 19849* (Holotype: LL!).

Erect or decumbent suffruticose, PERENNIAL SUBSHRUB branching mostly from base and above, 25--60cm tall, strigose, with 0.5--1.8 mm eglandular trichomes. STEMS robust, hispidulous-strigose to strigose. LEAVES mostly sessile (3 petiolate), linear, 7.0--57.0 mm long, 0.6--14.4 mm broad, moderately to dense strigose or hispidulous-strigose, glandular trichomes absent (two "present"). INFLORESCENCES with several subsessile to pedicel flowers in terminal cymes. PEDICELS 0.6--4.7 mm long. CALYCES divided to base. SEPAL LOBES linear, 7.0--11.4 mm long, ca. 3.7 mm broad at base, ca. 4.6 mm broad at apex, strigose; glandular trichomes usually absent, occasionally present. COROLLAS yellow or cream-colored, tubular or tubular-salverform, 7.8--11.1 mm long, corolla tube 2.2--7.8 mm broad when corollas are pressed flat and not dissected, corolla limb 2.1--6.4 mm broad, strigose or pubescent on adaxial (outer) surface; corolla lobes 1.1--5.7 mm broad at widest point. STAMENS unequal in length, shortest stamens 4.9--7.1 mm long, longest stamens 5.5--9.3 mm long, insertion unequal; adnate portion of filaments 2.4--7.0 mm long, winged; free portion of filaments 1.2--3.9 mm long. STYLE 3.9--5.3 mm long (including stigma). OVARY 1.3--2.9 mm long, 0.9--1.6 mm broad, sericeous toward apex. FRUITS sericeous or strigose at apex (holotype is pilose @apex), 3.7--5.4 mm long, 2.0--2.8 mm broad. FRUITING PEDICELS up to 5.4 mm long. SEEDS brown, mealy to mealy-reticulate, 0.5--0.8 mm long, 0.4--0.5 mm broad, 32--51 per capsule.

Phenology: Flowering and fruiting from May to November.

Distribution: Gypsum outcrops and calcareous arroyos and riverbeds; narrowly distributed in the vicinity of Galeana, Nuevo Leon (Figure 4.9).

Additional specimens examined: **MEXICO. Nuevo Leon.** Aramberri, La Ascension, gypsum hillside, 24^{o} 19' 25" N 99^{o} 54' 48" W, May 1991, *Hinton* 20950 (TEX); Galeana, La Poza 21.375 Km al SE carr a Rio de San Jose. Gypsum hillside, 24^{o} 34' 48" N 99^{o} 57' 54" W, 14 May 1991, *Hinton 21732* (TEX); Galeana, About 7 mi E of Ejido San Roberto N of Santo Domingo in the foothills of Cerro Potosi, low gypsum hills, 24^{o} 45' N 100^{o} 12' W, 24 Oct 1982, *Grimes 2312* (LL, TEX); Galeana, Entronque San Roberto, 7 mi al E carr a Galeana, calcareous alluvium near deep arroyo with forest of *Yucca australis*, 24^{o} 41' 42" N 100^{o} 11' 33" W, 8 Oct 1959, *Johnston 4211* (TEX); Galeana, Entronque San Roberto 17 mi al E on rocky hard gypsum outcrops on hillside S slope, 24^{o} 43' 8" N 100^{o} 3' 14" W, 1970, *Turner 6325* (TEX); Galeana, ca. 5 km NW of Village of Rio San Jose, Rio San Jose Canyon N side of river bed in canyon bottom, steep walls along rd, 24^{o} 38' N 99^{o} 55' W, 18 Sep 1993, *Nesom 7615* (TEX); Galeana, 29 Jul 1939, *Chase 7637* (GH); Galeana, 12 mi al NW de Galeana on gypsum outcrops, 24^{o} 53' 55" N 100^{o} 12' 42" W, 20 Aug 1979, *Turner A-36* (TEX); Galeana, 2.5 mi al S de Galeana on open eroded areas of clay soil under pines 400 yds from rd, 24^{o} 48' 1" N 100^{o} 3' 21" W, 6 Aug 1965, *Irving 147 (472)* (LL, TEX); Galeana, El Sauce, 5 Nov 1983, *Hinton 18084* (LL, TEX); Galeana, Santa Rita (Santa Rita de Cordeladas), gypsum slopes-pine woods, 24^{o} 48' 21" N 100^{o} 4' 35" W, 27 Sep 1981, *Hinton 18345* (TEX); Galeana, Santa Rita, 24^{o} 45' 12" N 100^{o} 16' 3" W, 1984, *Hinton 18785* (TEX); Rayones, 3k al S de Rayones, gypsum hillside, 24^{o} 59' 42" N 100^{o} 3' 54" W, 28 May 1989, *Hinton 19430* (LL, TEX); Ed. Nuevo Leon, intersection of road to Nva. Primera and road to Galeana coming from Hwy. 57, 26 Aug 1987, *Bogler 129* (LL, TEX); ca 1.8 mi NW of Galeana on rd to San Lucas on gyp hillside, 24^{o} 56' N 100^{o} 9' W, 25 Oct 1981, *Poole 2470* (TEX); Sta. Rita, proximidades al polbado de Galeana. 24^{o} 43' N y 100^{o} 06' W, 2150m, Bosque de Pinus arizonica, suelos yesosos, *MA Carranza* 1454 (LL, TEX) 12 May 1991.

Nama hitchcockii is a very narrowly-distributed, ostensibly nearly-obligate gypsophile. Two collections (*Johnston 4211* and *Irving 147*) specify "calcareous alluvium" and "eroded areas of clay soil under pines," respectively. These collections may be anomalies, with *N. hitchcockii* only very rarely occurring off of gypsum; alternatively, a collection bias may result in a skewed understanding of the species' preference. It is possible that *N. hitchcockii* frequently grows in calcareous habitats but has been overlooked. Further sampling of this species would help clarify this issue. The species is very woody, and herbarium specimens appear silvery-green due to the stiff, appressed white hairs on its leaves. Leaves are generally absent from the lower portions of the stems. The free-margined wings of the adnate portions of the stems are remarkably broad, far wider than observed in the other species of this group (approximately 1 mm at the apex).

As discussed above, *Nama hitchcockii* is very closely related to *N. canescens* and can be distinguished from its sympatric relative by its much longer leaves (approaching 6 mm at the longest) and cream or white flowers.

7. ***Nama "jimulco"*** in prep. TYPE: MEXICO. Coahuila. Mpio. Torreon, Sierra de Jimulco, 150 km al E de la mina de San Jose, 25°6'N, 103°13'W, 2100m. 21 Oct 1989, *J.A. Villarreal, P.A. Fryxell, J. Valdes, and P. Peterson 5523* (Holotype: MO!).

PERENNIAL HERB (?), height undetermined, sparsely pilose to hirsute-hispid, with 0.5—1.2 mm eglandular trichomes. STEMS robust, hirtellous to pilose. LEAVES sessile, narrowly lanceolate or narrowly elliptic, 17.5--41.1 mm long, 1.2--4.1 mm broad, sparsely pilose to hirsute-hispid, very densely glandular. INFLORESCENCES with 2-several flowers borne on sturdy pedicels in terminal cincinni. PEDICELS ca. 2.8 mm long. CALYCES divided to base. CALYX LOBES linear or linear-lanceolate, 9.4--10.0 mm long, ca. 1.1 mm broad at base, ca. 0.7 mm broad at apex, hirtellous; glandular trichomes present. COROLLAS purple, tubular-salverform, 13.9--16.4 mm long, corolla tube 2.5--5.4 mm broad when corollas are pressed flat and not dissected, corolla limb 8.8—10.1 mm broad, pilose-hirsute on lobes on adaxial (outer) surface; corolla lobes 3.3--3.7 mm broad at widest point. STAMENS subequal in length, shortest stamens ca. 11.5 mm long, longest stamens ca. 12.5 mm long, insertion subequal; adnate portion of filaments 8.0--8.8 mm long, winged, with prominent curved teeth at apices of wings; free portion of filaments ca. 3.5 mm long. STYLE 8.3 mm long (including stigma). OVARY 2.8 mm long, 1.5 mm broad, puberulent at the apical half. FRUITS hirtellous at apex, 5.4 mm long, 3.6 mm broad. FRUITING PEDICELS up to 3.0 mm long. SEEDS brown, alveolate, granular, 0.7 mm long, 0.6 mm broad, number of seeds per capsule unknown.

Phenology: Flowering and fruiting from August to October.

Distribution: Shrubland (matorral) of *Agave*, *Gochnatia*, *Acacia*, *Cercocarpus*, *Lindleya*, and *Vauquelinia* in the Sierra de Jimulco of Coahuila (Figure 4.10); substrate preference (if any) unknown at this time.

Additional specimens examined: **MEXICO. Coahuila.** Mina San Jose, approx. 10 km al NE de la Flor de Jimulco, 25o6’30”N, 103o13’30”W, Alt. 2150m.

Nama "jimulco" bears leaves that are intermediate in width between *N. johnstonii* and *N. constancei* (its closest relatives as ascertained from the molecular phylogeny presented in Chapter 2) and those of *N. havardii*. The winged portions of adnate stamen filaments are toothed, as are those of *N. constancei*. The two specimens that we have examined do not include substrate information on the herbarium label, so whether *N. "jimulco"* prefers gypsum or limestone remains to be seen.

8. *Nama johnstonii* C.L. Hitchc., Am. J. Bot 26(5): 344. 1939. TYPE: MEXICO. Coahuila. 6 miles west of Viesca, on limestone cliffs in steep canyon, 17 Sep 1938, *I.M. Johnston 7740* (Holotype: GH! Isotype: US!).

Rounded, PERENNIAL SUBSHRUB branching mostly from base and above, 20--35 cm tall, hirsute or pilose, with 0.1--1.5 mm eglandular trichomes. STEMS robust, hirtellous to pilose. LEAVES sessile, linear, occasionally narrowly spatulate or oblanceolate, 8.1--41.1 mm long, 1.0--4.1 mm broad, moderately pilose to hirsute or strigose or hispid, glandular trichomes present, sometimes sparsely or only at the base of the leaves. INFLORESCENCES with 2-several subsessile to pedicellate flowers in terminal cymes (or on short lateral branches). PEDICELS 0.9--3.9 mm long. CALYCES divided to base. SEPAL LOBES linear or linear-lanceolate, 4.1--10.0 mm long, ca. 1.4 mm broad at base, ca. 0.8 mm broad at apex, pilose to hirsute-hispid; glandular trichomes present. COROLLAS white or purple, tubular or tubular-salverform, 7.7--16.4 mm long, corolla tube 1.8--5.4 mm broad when corollas are pressed flat and not dissected, corolla limb 2.3--10.1 mm broad, hirtellous on lobes on adaxial (outer) surface; corolla lobes 1.3--3.7 mm broad at widest point. STAMENS unequal in length, shortest stamens 2.9--11.5 mm long, longest stamens 4.3--12.5 mm long, insertion subequal to unequal; adnate portion of filaments 1.1--8.8 mm long, winged; free portion of filaments 1.6--3.5 mm long. STYLE 2.3--8.8 mm long (including stigma). OVARY 1.2--2.9 mm long, 0.5--1.5 mm broad, pubescent all over, longer at top half, appr. Pilo. FRUITS pubescent or hirtellous at apex, 2.4--5.4 mm long, 1.6--3.6 mm broad. FRUITING PEDICELS up to 4.3 mm long. SEEDS brown, finely alveolate, granular, 0.4--0.7 mm long, 0.3--0.6 mm broad, 12--60 per capsule.

Phenology: Flowering and fruiting from May to October.

Distribution: Steep limestone or shale hillsides and cliffs in the vicinity of Parras and Zaragoza in Coahuila state (Figure 4.11).

Additional specimens examined: **MEXICO. Coahuila.** Parras de La Fuente, S of shale hillside with xerophilus scrub, 25^{o} 25’ 47” N 102^{o} 10’ 36” W, 19 Sep 1993, *Hinton 23340* (LL, TEX); Ejido el Capulin aprox 10 km al SW de Parras de la Fte.; Sa de Parras, vegetacion de *Pinus pinceana P. cembroides Juniperus monosperma Lindleyella mespiloides Cowania plicata*, 25^{o} 23’ N 102^{o} 13’ W, 8 Jun 1984, *Rodriguez 2402* (LL, TEX); Tanque Menchaca roadside shale hillside, S slope of Sierra de Parras, 25^{o} 20’ 30” N 102^{o} 11’ 33” W, 28 Aug 1999, *Hinton 27443* (LL, TEX); Jimulco, mt walls, 14 May 1885, *Pringle 120* (GH [labeled “Chihuahua”], NY, US, LL, TEX); crevices on exposed cliff-faces, 2 Sep 1941, *Johnston 8739* (GH); 6 mi. NW of Viesca Mountain slopes. topotype, 17 Sep 1938, *Shreve 8774* (US); Jimulco, collected from limestone slopes, 14 May 1885, *Pringle s.n* (NY).

Nama johnstonii is unique among species of the *Nama stenophylla* clade by virtue of the fact that it has not been collected from gypsum. Instead, it is notably endemic to limestone and shale deposits. Free portions of the stamens are very short – the adnate portions are 2.5 – 5 times as long as the free portion

9. *Nama stenophylla* A. Gray in Hemsl., Biol. Cent. Am. Bot. 2: 361. 1882. TYPE: MEXICO. Coahuila. San Lorenzo de Laguno, *E. Palmer 861* (Holotype: K; Isotypes: GH! NY!).

Conanthus stenophyllus (A. Gray) A. Heller, Cat. N. Amer. Pl. 6. 1898. *Marilaunidium stenophyllum* (A. Gray) Kuntze Rev. Gen. Pl. 2: 434. 1891.

Bushy, suffrutescent, PERENNIAL HERB branching mostly from above the base, 25--30cm tall, hirsute-hispid, with 0.2--2.4 mm eglandular trichomes. STEMS robust, hirtellous or hirsute-hispid with a shorter hirsute, pubescent, or velutinous underlayer. LEAVES sessile, linear, 9.7--34.3 mm long, 0.9--2.4 mm broad, moderately to dense hirtellous or pubescent to hirsute-hispid, glandular trichomes usually present but sometimes absent. INFLORESCENCES with 1-5 pedicel flowers in axils and terminal cymes. PEDICELS 1.2--4.2 mm long. CALYCES divided to base. SEPAL LOBES linear or linear-lanceolate to narrowly spatulate, 4.3--8.3 mm long, ca. 1.2 mm broad at base, ca. 1.0 mm broad at apex, hirsute, hispid, or hirsute-hispid; glandular trichomes present. COROLLAS pink (light or dark) or purple, salverform, occasionally funnelform, 6.6--12.8 mm long, corolla tube 1.7--3.1 mm broad when corollas are pressed flat and not dissected, corolla limb 3.6--9.7 mm broad, hirtellous or pubescent, often just on lines centered on limb on adaxial (outer) surface; corolla lobes 1.4--4.1 mm broad at widest point. STAMENS unequal in length, shortest stamens 3.5--5.8 mm long, longest stamens 4.9--8.7 mm long, insertion unequal; adnate portion of filaments 2.0--7.6 mm long, narrowly winged; free portion of filaments 1.0--1.9 mm long. STYLE 2.4--5.0 mm long (including stigma). OVARY 1.1--3.8 mm long, 0.6--1.9 mm broad, pilose, hirtellous, or pubescent at apex. FRUITS puberulent or hirtellous at apex, 3.2--5.4 mm long, 1.9--2.8 mm broad. FRUITING PEDICELS up to 4.8 mm long. SEEDS brown, reticulate, 0.4--0.9 mm long, 0.3--0.6 mm broad, 48--86 per capsule.

Phenology: Flowering and fruiting from April to October.

Distribution: Gypsum flats and knolls; widespread in eastern Chihuahua, across Coahuila, to Durango and Nuevo Leon (Figure 4.12).

Additional specimens examined: **MEXICO. Chihuahua.** Ahumada, 22.5 mi S of El Sueco on Hwy 45, roadside, 29° 35’ 30” N 106° 21’ 10” W, 28 Apr 1986, *Nesom 5257* (LL, TEX); 15 miles S of Cd. Carmargo (sic) along Mexico hwy 45 on rocky flats of Chihuahuan Desert; with *Larrea, Acacia, Flourensia, Parthenium, Prosopis, Krameria, Opuntia*, etc., 27° 31’ N 105° 1’ W, 24 Aug 1971, *Henrickson 5902* (LL, TEX); 9 km NE of Carrillo toward Guimbalete, N of railrd, Matorral desiertico inerme. *Flourensia cernua Citharexylum Cevallia Zinnia*, 26° 56’ 40” N 103° 53’ W, 31 Aug 1972, *Johnston 9048* (LL, TEX); 6 Sep 1941, *Bryan s.n.* (GH); **Coahuila.** Cuatrocienegas, 76.3 mi W of Cuatrocienegas de Carranza (Cuatrocienegas) on dirt rd along railrd track to Esmeralda, gyp flat with small gypsum knolls, basin area, with *Nerisyrenia Selinocarpus Anulocaulis*, 27° 8’ 8” N 103° 11’ 7” W, 17 Oct 1971, *Bacon 1153* (LL, TEX); Cuatrocienegas, 33 mi SSW of Cuatrocienegas de Carranza (Cuatrocienegas) on Rd to

San Pedro, gypsiferous outcrop in *Larrea* Desert, 26° 38' 47" N 102° 24' 22" W, 16 Oct 1972, *Gentry 23140* (TEX); Cuatrocienegas, dunas cercanas a la Poza de la Becerra en Cuatrocienegas, vegetacion gypsofila de: *Allenrolfea Atriplex Nama Pseudoclappia arenaria* y *Sesuvium verrucosum*, 26° 53' N 102° 7' W, 26 Oct 1985, *Villarreal 3209* (LL, TEX); San Pedro, along Hwy Mex 30, 108 km by rd NE of San Pedro de Las Colonias, grazed desert on gentle slopes, *Larrea tridentata* common with species diversity greatest along the Hwy, 26° 32' 5" N 102° 28' 45" W, 27 Jul 1982, *Nee 25357* (LL, TEX); Gypsum outcrop, ca. 20 km NNE of Torreon, on the road to Laguna del Rey from just E of Finisterre. 51.8 mi. from jct. C-41 (road to Laguna del Rey) and rd. E of Finisterre, and 56.1 mi. N of fork in rd. near Finisterre, north facing slope with agave, *Fouquieria, Acacia, Yucca, Boerhaavia, Dalea, Opuntia, Nama, Epithelantha, Echinocereus, Mammillaria*, 26° 39' 10" N 103° 10' 3" W, 13 Sep 1996, *Porter 11275* (LL, TEX); ca 62 (air) miles SW of Cuatro Cienegas, 10 (rd) miles NE of turnoff to Las Delicias on San Pedro-Cuatro Cienegas Hwy; common along highway in gypsum knolls; with *Acacia, Fouquieria shrevei, Petalonyx, Atriplex, Opuntia* ssp., 26° 19' N 102° 39' W, 18 Aug 1973, *Henrickson 12531* (LL, TEX); 23 Sep 1942, *Stewart 2722* (GH); 3 Oct 1942, *Stewart 2834* (GH); Cerro de la Carroza, west of Candela on Highway 30 to Monclova, gypsum slope below massive limestone ridge, just east of roadside shrine at Rancho Sta. Lucia, gypsum slope below massive limestone ridge in *Agave, Yucca, Opuntia* grassland, 26° 50' N 100° 45' W, 18 Oct 1993, *Patterson 7438* (LL, TEX); 3 Km SW of Cuatro Cienegas, 26° 58' N 102° 5' W, 11 Jun 1972, *Chiang C 7609* (LL, TEX); 64 (rd) miles W of Cuatro Cienegas, (6 miles W of La Vibora) on small gypsum knoll near railroad, in Bolson de Mapimi region of Chihuahuan Desert, common on gypsum, with *Larrea, Atriplex, Nama, Petalonyx, Oenothera*, etc., 27° 9' N 103° 3' W, 21 Sep 1972, *Henrickson 7864* (LL, TEX); 5 Sep 1941, *Johnston 8866* (GH); 16 Km SW of

Cuatro Cienegas W of the Torreon Hwy, zacatonal or izotal, with *Dasylirion Sporobolus Prosopis glandulosa Petalonyx*, 26^{o} 52' N 102^{o} 9' W, 4 Sep 1972, *Chiang 9160* (LL, TEX); 22 Sep 1941, *Johnston 9341* (G, LL, TEX); **Durango.** 66 miles N of N. Gomez Palacio along Hwy 49, 1.3 miles S of Est. Yermo in open Chihuahuan Desert, with *Larrea, Prosopis, Parthenium*, etc., 26^{o} 23' N 103^{o} 59' W, 23 Sep 1972, *Henrickson 7976* (LL, TEX); **Nuevo Leon.** 7 mi NE of Las Estacas (about midway between Monclova and Minas on Hwy 53) on private ranch rd towards *Lechuguilla* Grassland with many herbs including *Machaeranthera Tiquilia Nama* etc, 26^{o} 25' N 100^{o} 48' W, 18 Oct 1993, *Prather 1487* (LL, TEX);

Nama stenophylla is one of the most widespread and common species in this group. This obligate gypsophile is grayish-green both in the field and on herbarium specimens, and bears pink flowers. I have observed many plants in the field that were entirely herbaceous, but have also seen herbarium specimens (e.g., *Henrickson 12531*, TEX) that are clearly woody at the base. While the bases can be woody, the plants are not shrubby. The plants are scarcely branching at the base, more often branching higher up from a single stout stem.

Table 4.1. Geographic distribution of 56 species of *Nama*. Abbreviations for non-USA states are as follows: **ARG (Argentina)** - CAT (Catamarca), CHIL (Chilecito), COR (Cordoba), JUJ (Jujuy), MEN (Mendoza), SAL (Salta), SJ (San Juan), TUC (Tucuman); **BOL (Bolivia)**; **Chile** – ATA (Atacama); GUAT (Guatemala) – HUE (Huehuetenango), MAR (San Marcos), SOL (Solola); **MEX (Mexico)** – BCS (Baja California Sur), CHI (Chihuahua), CHIA (Chiapas), COA (Coahuila), DF (Distrito Federal), DUR (Durango), GUA (Guanajuato), HID (Hidalgo), JAL (Jalisco), MEX (Estado de Mexico), MICH (Michoacan), NL (Nuevo Leon), OAX (Oaxaca), PUE (Puebla), QUE (Queretaro), SIN (Sinaloa), SLP (San Luis Potosi), SON (Sonora), TAM (Tamaulipas), VER (Veracruz), YUC (Yucatan), ZAC (Zacatecas); **Peru** – AMB (Ambo), ARE (Arequipa), LIB (La Libertad), TAC (Tacna), TRU (Trujillo).

SPECIES	**DISTRIBUTION**
N. aretioides (Hook. and Arn.) Brand	**USA**: CA, ID, NV, OR
N. berlandieri A. Gray	**MEX**: TAM; **USA**: TX
N. bartlettii Standl.	**MEX**: VER, TAM
N. biflora Choisy	**MEX**: HID, NL, QUE, SLP, TAM
N. californica (A. Gray) J.D. Bacon	**USA**: CA, NV
N. canescens C.L. Hitchc.	**MEX**: NL, SLP
N. carnosa (Wooton) C.L. Hitchc.	**USA**: NM, TX
N. constancei J.D. Bacon	**MEX**: COA, DUR
N. coulteri A. Gray	**MEX**: BCS, SIN, SON
N. cuatrocienegensis G.L. Neesom	**MEX**: COA
N. demissa A. Gray	**MEX**: BCS, CHI; **USA**: AZ, CA, NV, UT
N. densa Lemmon	**USA**: CA, ID, NV, OR

Table 4.1 (continued)

SPECIES	**DISTRIBUTION**
N. depressa Lemmon ex A. Gray	**USA**: CA
N. dichotoma (Ruiz and Pav.) Choisy	**ARG**: CAT; BOL: GLO; **CHILE**; **ECUADOR**; **GUAT**; **MEX**: CHIA, CHI, COA, DF, DUR, HID, NL, OAX, PUE, SLP, VER, ZAC; **PERU**: AMB, ARE, LIB, TAC, TRU; **USA**: AZ, NM, TX
N. ehrenbergii Brand	**MEX**: HID?
N. flavescens Brandegee	**MEX**: COA, ZAC
N. havardii A. Gray	**MEX**: CHI, COA, NL; **USA**: TX
N. hintoniora G.L. Neesom	**MEX**: COA, NL, TAM
N. hirsuta M. Martens and Galeotti	**GUAT**: HUE, MAR, SOL; **MEX**: OAX
N. hispida A. Gray	**ME**X: BC, CHI, COA, DUR, NL, SLP, SIN, SON, TAM, VER, ZAC; **USA**: AZ, CA, NM, OK, TX
N. hitchcockii J.D. Bacon	**MEX**: NL
N. jamaicensis L.	**ARG**: COR, JUJ, LA RIOJA, SAL, TUC; **CARIB**; **MEX**: COA, JAL, MICH, NL, SLP, SIN, SON, TAM, VER, YUC; **TRINIDAD AND TOBAGO**; **USA**: FL, LA, TX
N. johnstonii C.L. Hitchc.	**MEX**: COA
N. linearis I.M. Johnst.	**MEX**: VER
N. marshii (Standl.) I.M. Johnst.	**MEX**: COA, SLP
N. origanifolia H.B.K.	**MEX**: DUR, GUA, HID, MICH, SLP, VER
N. orizabensis D.L. Nash	**MEX**: VER
N. palmeri A. Gray ex Hemsl.	**MEX**: COA, HID, NL, SLP, TAM, ZAC
N. parviflora (Greenm.) Constance	**USA**: CA, ID, NV, OR, UT, WA
N. parvifolia (Torr.) Greenm.	**MEX**: COA, NL, TAM; **USA**: TX

Table 4.1 (continued)

N. pringlei B.L. Rob. and Greenm.	**MEX**: HID, OAX, PUEB, SLP
SPECIES	**DISTRIBUTION**
N. propinqua C.V. Morton and C.L. Hitchc.	**MEX**: COA, NL
N. prostrata Brand	**MEX**: JAL, MICH, MEX
N. pueblensis B.L. Rob. and Greenm.	**MEX**: PUE, COA, QUE, SLP
N. pusilla Lemmon ex A. Gray	**USA**: CA
N. quiexobrana J.D. Bacon and J.A. McDonald	**MEX**: OAX
N. retrorsa J.T. Howell	**USA**: AZ, NM, UT
N. rotundifolia (A. Gray) J.F. Macbr.	**MEX**: COA, NL
N. rzedowskii J.D. Bacon	**MEX**: SLP
N. sandwicensis A. Gray	**USA**: HI
*N. schaffner*i A. Gray ex Hemsl.	**MEX**: COA, NL, SLP; **USA**: TX
N. segetalis Ricketson	**GUA**: HUE
N. sericea Willd. ex Roem. & Schult.	**MEX**: DF, GUA, HID, QUE, SLP, NL, TAM
N. serpylloides A. Gray ex Hemsl.	**MEX**: COA, NL
N. spathulata Brandegee	**MEX**: NL, PUE
N. stenocarpa A. Gray	**MEX**: BCS, SIN, TAM; **USA**: AZ, CA, TX
N. stenophylla A. Gray ex Hemsl.	**MEX**: CHI, COA, DUR, NL, SLP
N. stevensii C.L. Hitchc.	**MEX**: COA, NL, ZAC; USA: KA, NM, OK, TX
N. torynophylla Greenm.	**MEX**: CHI, COA, SON; USA: AZ, TX
N. turneri J.D. Bacon	**MEX**: NL, SLP

Table 4.1 (continued)

N. undulata H.B.K.	**ARG**: CAT, CHIL, COR, LA RIOJA, MEN, SAL, SJ, TUC; **CHILE**: ATA; **MEX**: CHI, COA, DUR, GUA, HID, JAL, MEX, NL, OAX, PUE, SLP, SIN, SON, TAM, VER, ZAC; **USA**: TX
N. xylopoda Wooton and Standl.	**USA**: NM, TX
SPECIES	**DISTRIBUTION**
N. "baconii"	**MEX**: VER
N. "Jimulco"	**MEX**: COA
N. "monclova"	**MEX**: SLP
N. "whalenii"	**MEX**: COA, NL, QUE

Table 4.2. Authors publishing new species and varieties of *Nama* between 1791 and 1890.

Author	Number of species / Number of varieties	Publications
A. Gray	10 / 1	1861. Proc. Amer. Acad. Arts 5: 37, 338-339. 1864. Proc. Amer. Acad. Arts 6: 37. 1870. Proc. Amer. Acad. Arts 8: 282-284. 1875. Proc. Amer. Acad. Arts 10: 331. 1885. Proc. Amer. Acad. Arts 20: 304.
Bonpland	2 / 0	1833. Mem. Soc. Phys. Geneve 6: 114.
Choisy	3 / 2	1833. Ann. Sci. Nat. (Paris) 30: 242. 1846. Prodr. (DC.) 10: 182-183
Grisebach	1 / 0	1874. in Goett. Abh. 19: 230.
Kellogg	1 / 0	1873. Proc. Calif. Acad. Sci. 5: 51.
Lemmon	3 / 0	1885. Proc. Mer. Acad. Arts 20: 304. 1889. Bull. Torrey. Bot. Club 16: 222.
M. Martens & Galeotti	1 / 0	1845. Bull. Acad. Brux. 7: 277.
Pavon	1 / 0	1841. Nomencl. Bot., ed. 2 (Steudel) 2: 180
Philippi	1 / 0	1860. Fl. Atacam. 37.
Torrey	0 / 2	1858. Pacific Railr. Rep. 7, Pt. 3: 17. 1858. Rep. U.S. Mex. Bound., Bot. 147.
Willdenow	4 / 0	1820. Syst. Veg., ed. 15 bis [Roemer and Schultes] 6: 189 1845. Prodr. (DC.) 9: 447.

Table 4.3. Chromosome counts obtained from literature sources for species of *Nama*.

Species	**n=**	**Reference**
N. aretioides (Hook. and Arn.) Brand	7	Cave and Constance 1950, Bacon 1984
N. biflora Choisy	7	Bacon 1984
N. canescens C.L. Hitchc.	7	Bacon 1974, Bacon 1984
N. carnosa (Wooton) C.L. Hitchc.	7	Bacon 1974, Bacon 1984
N. coulteri A. Gray	7	Cave and Constance 1950,Bacon 1974, Bacon 1984
N. demissa A. Gray	7	Cave and Constance 1947, Cave and Constance 1950, Bacon 1984
N. demissa A. Gray var. *linearis*	14	Cave and Constance 1950
N. densa Lemmon	7	Bacon 1984
N. densa Lemmon	14	Cave and Constance 1947
N. depressa Lemmon ex A. Gray	7	Cave and Constance 1959, Bacon 1984
N. dichotoma (Ruiz and Pav.) Choisy	c. 22	sporophyte count: Diers 1961
N. dichotoma (Ruiz and Pav.) Choisy var. *chasmogama* Brand	7	Bacon 1984
N. dichotoma (Ruiz and Pav.) Choisy	14	Bacon 1984
N. pueblensis B.L. Rob. and Greenm.	14	Bacon 1984
N. flavescens Brandegee	7	Bacon 1984
N. havardii A. Gray	7	Bacon 1974
N. hirsuta M. Martens and Galeotti	7	Bacon 1984
N. hispida A. Gray	7	Tyrl et al. 1984, Cave and Constance 1947, Cave and Constance 1950, Kuzmanov and Nikolova 1977,Bacon 1974
N. hispida A. Gray var. *gypsicola* I.M. Johnston	7	Bacon 1974
N. hispida A. Gray var. *mentzelii* Brand	7	Bacon 1974, Bacon 1984, Ward 1983, Ward 1984
N. hispida A. Gray var. *sonorae* C.L. Hitchc.	7	Bacon 1984
N. hispida A. Gray var. *spathulatum* (Torr.) C.L. Hitchcock	7	Bacon 1974
N. hitchcockii J.D. Bacon	7	Bacon 1984
N. jamaicensis L.	7	Bacon 1974
N. jamaicensis L.	14	Cave and Constance 1950, Bacon 1974, Bacon 1984

Table 4.3 (continued)

N. johnstonii C.L. Hitchc.	7	Bacon 1974
N. origanifolia H.B.K.	7	Bacon 1974, Bacon 1984
N. palmeri A. Gray ex Hemsl.	7	Bacon 1974, Bacon 1984
N. parviflora (Greenm.) Constance	7	Bacon 1984, Cave and Constance 1950
N. parviflora (Greenm.) Constance	14	Cave and Constance 1950
N. parvifolia (Torr.) Greenm.	7	Bacon 1984
N. pringlei B.L. Rob. and Greenm.	7	Bacon 1984
N. propinqua C.V. Morton and C.L. Hitchc.	7	Bacon 1984
N. prostrata Brand	7	Bacon 1984
N. pusilla Lemmon ex A. Gray	7	Cave and Constance 1959, Bacon 1984
N. quiexobrana J.D. Bacon and J.A. McDonald	7II	Bacon and McDonald 1991
N. retrorsa J.T. Howell	7	Bacon 1984
N. rotundifolia (A. Gray) J.F. Macbr.	7	Bacon 1984
N. sandwicensis A. Gray	7	Carr 1978, Bacon 1984
N. sericea Willd. ex Roem. & Schult.	7	Cave and Constance 1950, Bacon 1984
N. serpylloides A. Gray ex Hemsl. var. *confertum* I.M. Johnst.	7	Bacon 1984
N. serpylloides A. Gray ex Hemsl. var *velutinum*	7	Bacon 1974, Bacon 1984
N. serpylloides A. Gray ex Hemsl. var. *velutinum* C.L. Hitchcock	14	Bacon 1974
N. stenocarpa A. Gray	7	Cave and Constance 1950
N. stenophylla A. Gray ex Hemsl.	7	Bacon 1974
N. stevensii C.L. Hitchc.	7	Cave and Constance 1959, Bacon 1974, Bacon 1984, Tyrl et al 1984, Kuzmanov and Nikolova 1977
N. turneri J.D. Bacon	7	Bacon 1984
N. undulata H.B.K.	7	Cave and Constance 1950,Cave and Constance 1959, Bacon 1974, Bacon 1984
N. xylopoda Wooton and Standl.	7	Bacon 1984

Table 4.4. Selected morphological characteristics and geographical distributions of the nine species of the *Nama stenophylla* lineage. Abbreviations of Mexican states names are as follows: Chihuahua (CHI); Coahuila (COA); Durango (DUR); Nuevo Leon (NL); San Luis Potosi (SLP); Zacatecas (ZAC).

	N. canescens	***N. carnosa***	***N. constancei***	***N. flavescens***	***N. havardii***	***N. hitchcockii***	***N. "jimulco"***	***N. johnstonii***	***N. stenophylla***
Leaf length (mm)	6-30	8-48	14-48	4.5-33	7-57	7-57	17-41	8.1-31.5	9.7-34.3
Corolla length (mm)	5-8	7-10	10-14	6-10	7-14	8-11	14-17	8-12.7	6-13
Corolla color	pink, purple, or rose-red	white	pale pink or white	pink or purple	pink or purple	yellow or cream	not observed	white	pink or purple
Style length (mm)	1.5-2.2	2.2-4	5.7-8.0	2.6-3.1	3.0-4.7	4-5.5	8.3	2.3-8.8	2.4-5
Free margins of stamens toothed?	No	No	Yes	No, or minute	No	No	Yes	No	No
Woodiness	not woody	woody throughout	woody	not woody	not woody	very woody	not observed	woody	woody
Distribution	Mexico: NL, SLP	US: NM, TX	Mexico: COA	Mexico: COA, ZAC	US: TX; Mexico: CHI, COA	Mexico: NL	Mexico: COA	Mexico: COA	Mexico: CHI, COA, DUR, NL

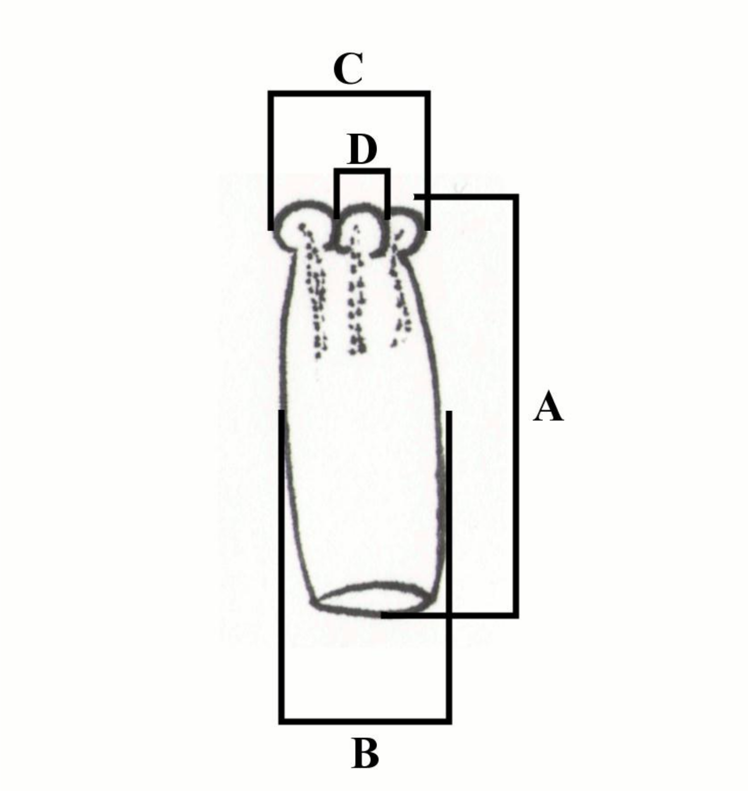


Figure 4.1: Line drawing of a corolla of *Nama carnosa*, drawn from *Wooton 164* (US!), an isotype of the species, to illustrate how corolla measurements were ascertained. A. Corolla length. B. Tube width. C. Limb width. D. Lobe width.

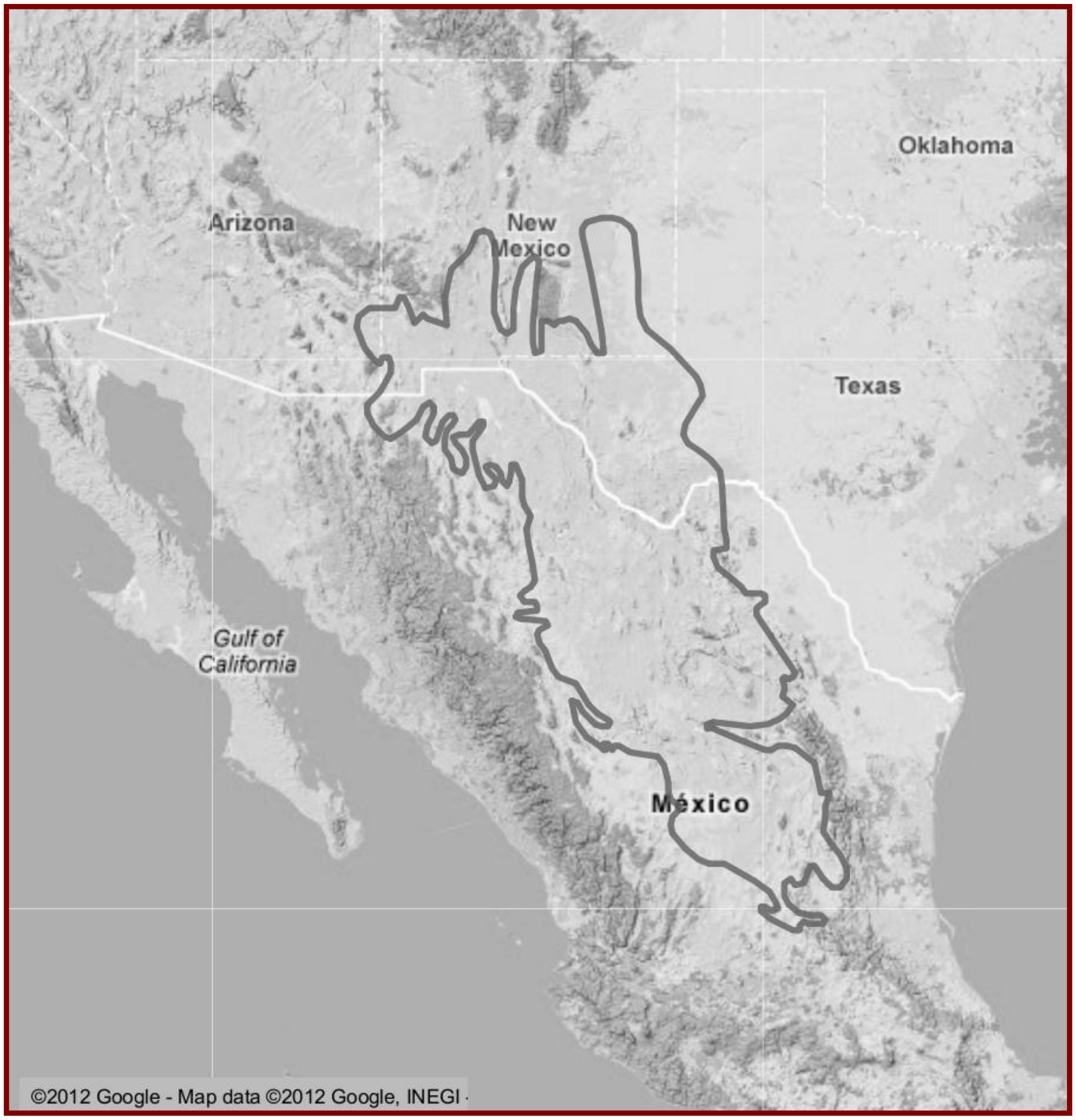


Figure 4.2: Map of the Chihuahuan Desert Region, adapted from Henrickson and Garcia (1976).

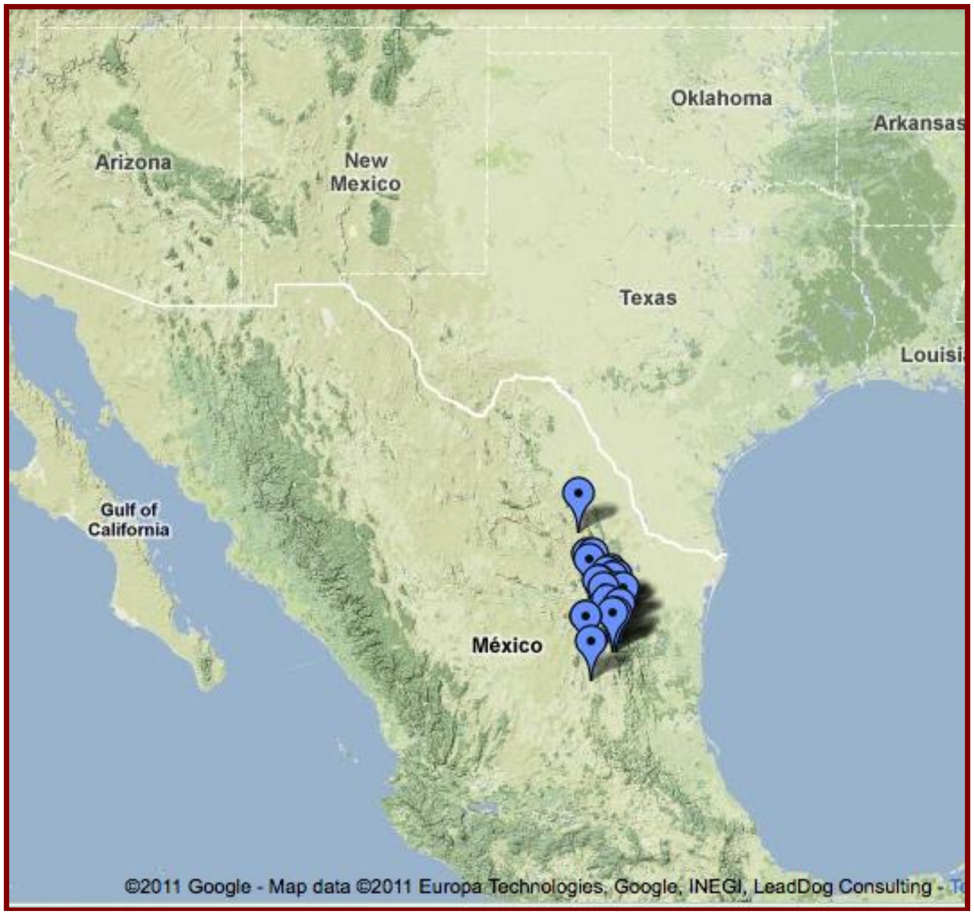


Figure 4.3: Geographic distribution of *Nama canescens*

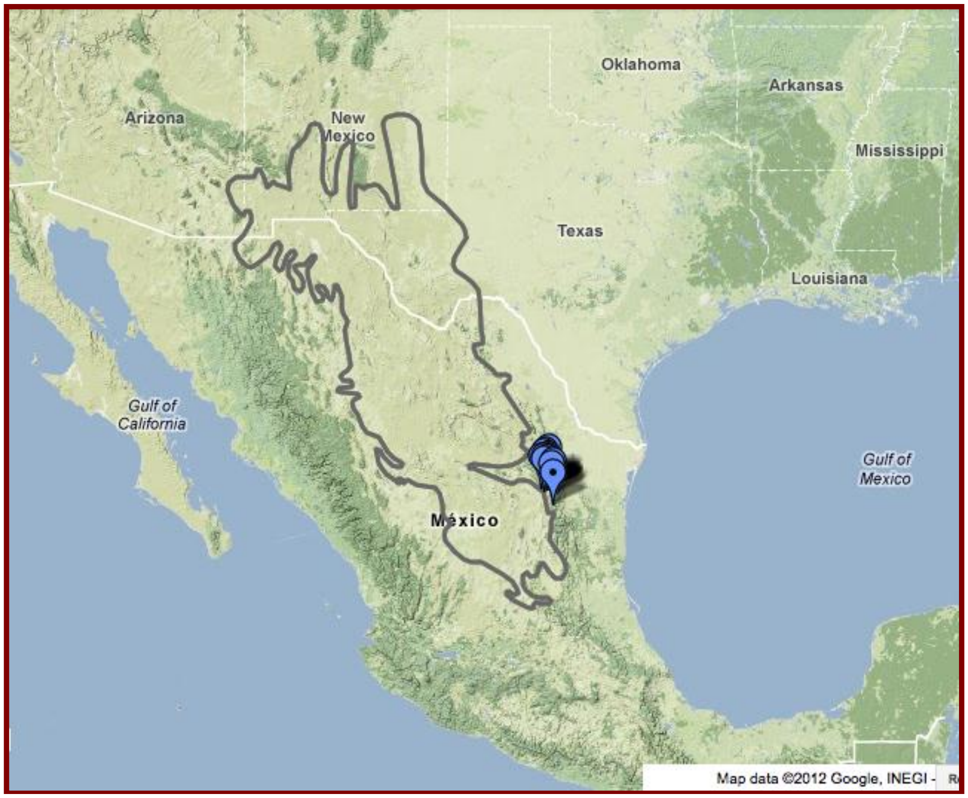


Figure 4.4: Geographic distribution of *Nama hitchcockii*.

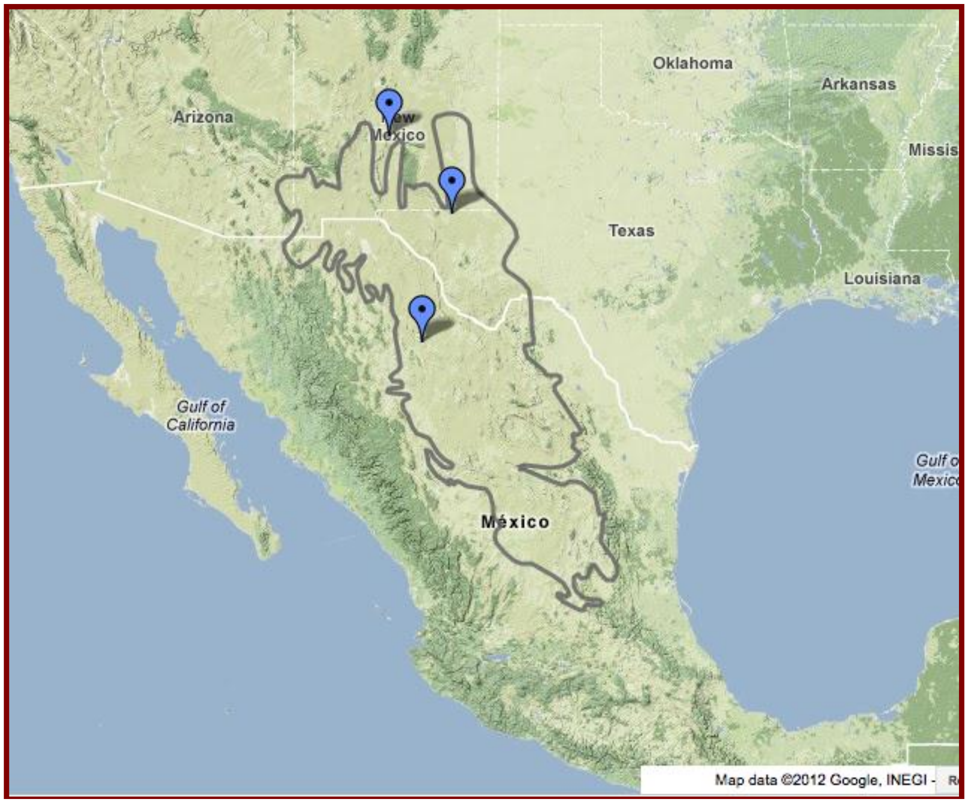


Figure 4.5: Geographic distribution of *Nama carnosa*.

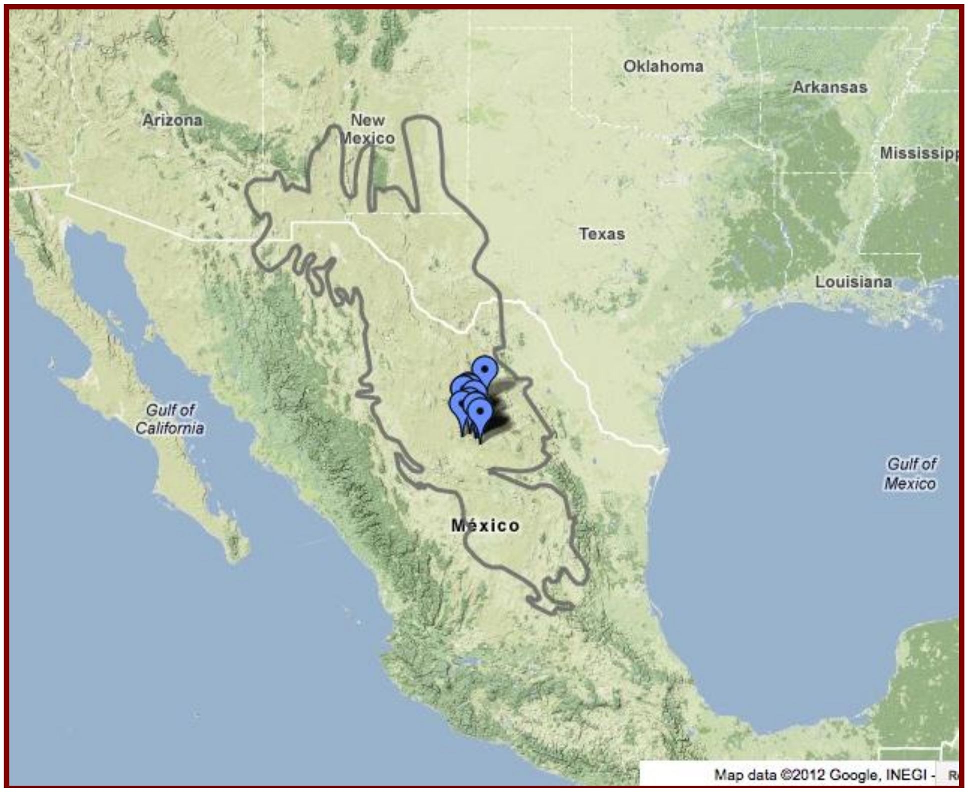


Figure 4.6: Geographic distribution of *Nama constancei*.

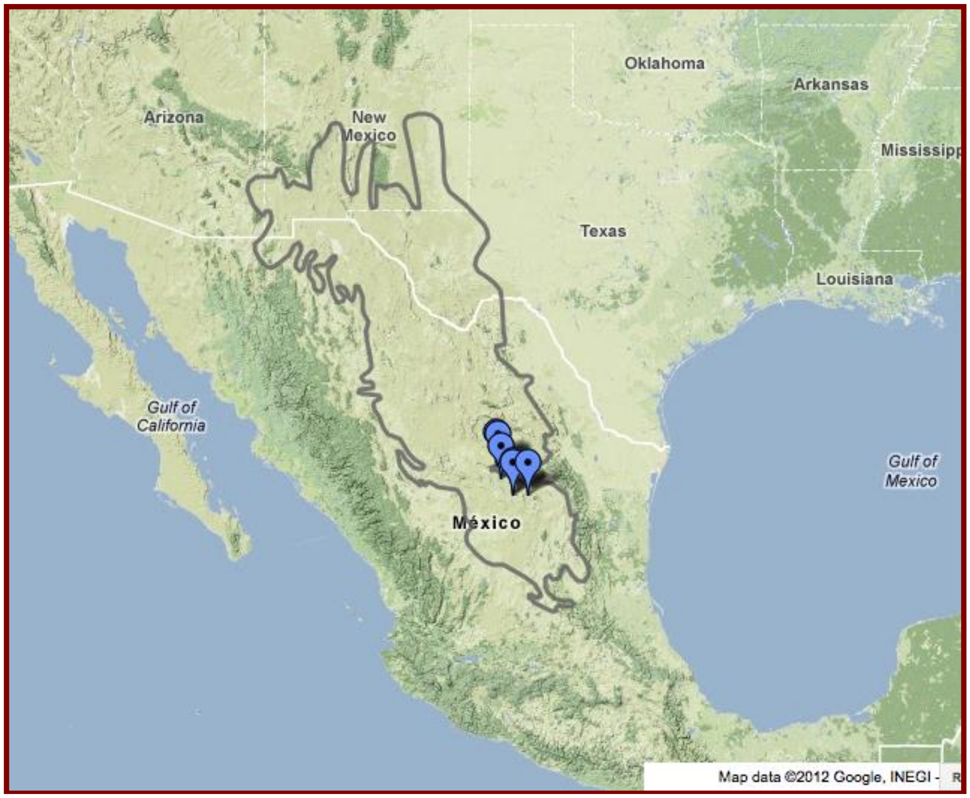


Figure 4.7: Geographic distribution of *Nama flavescens*.

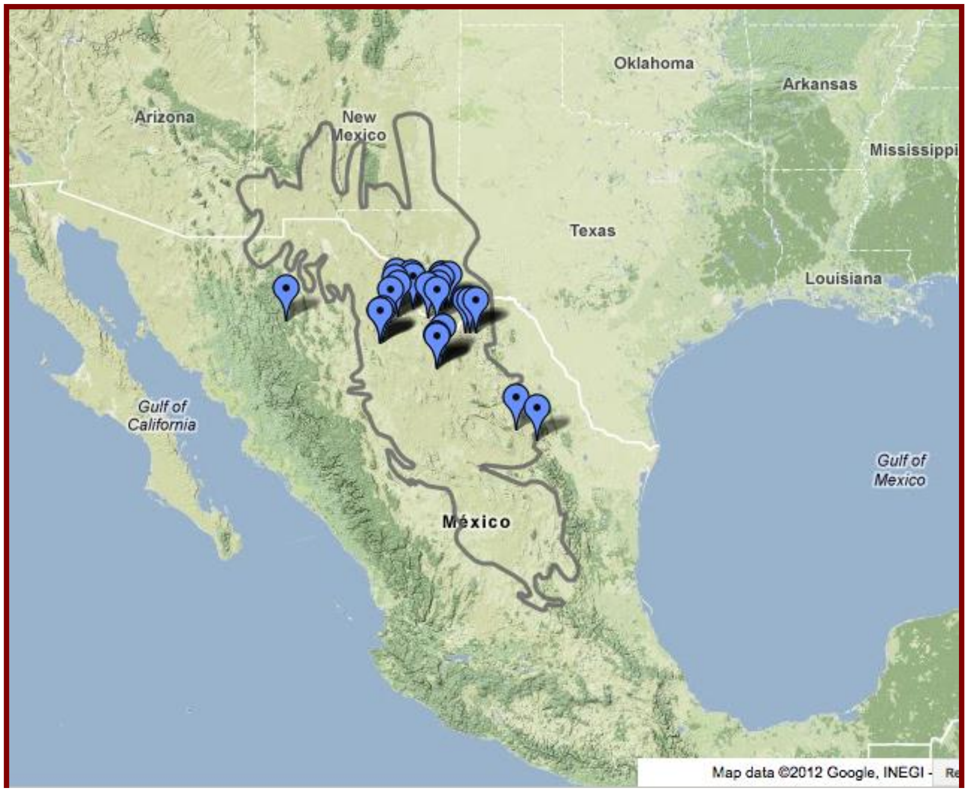


Figure 4.8: Geographic distribution of *Nama havardi.*

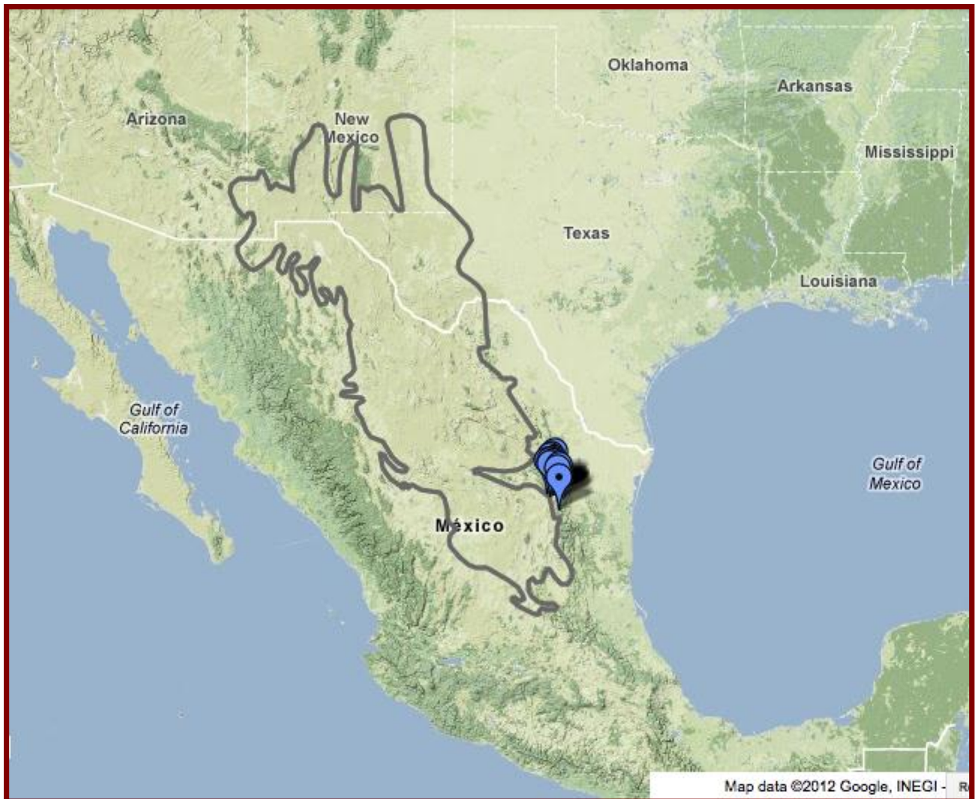


Figure 4.9: Geographic distribution of *Nama hitchcockii.*

Figure 4.10: Geographic distribution of *Nama "jimulco."*

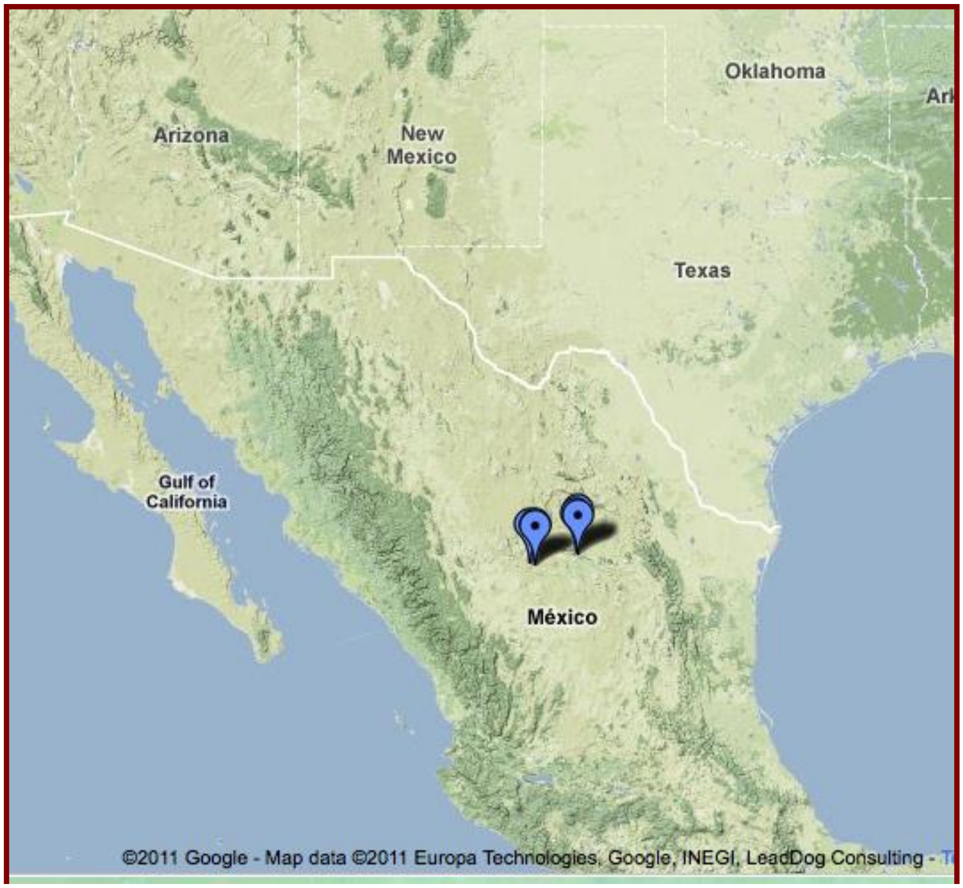


Figure 4.11: Geographic distribution of *Nama johnstonii*.

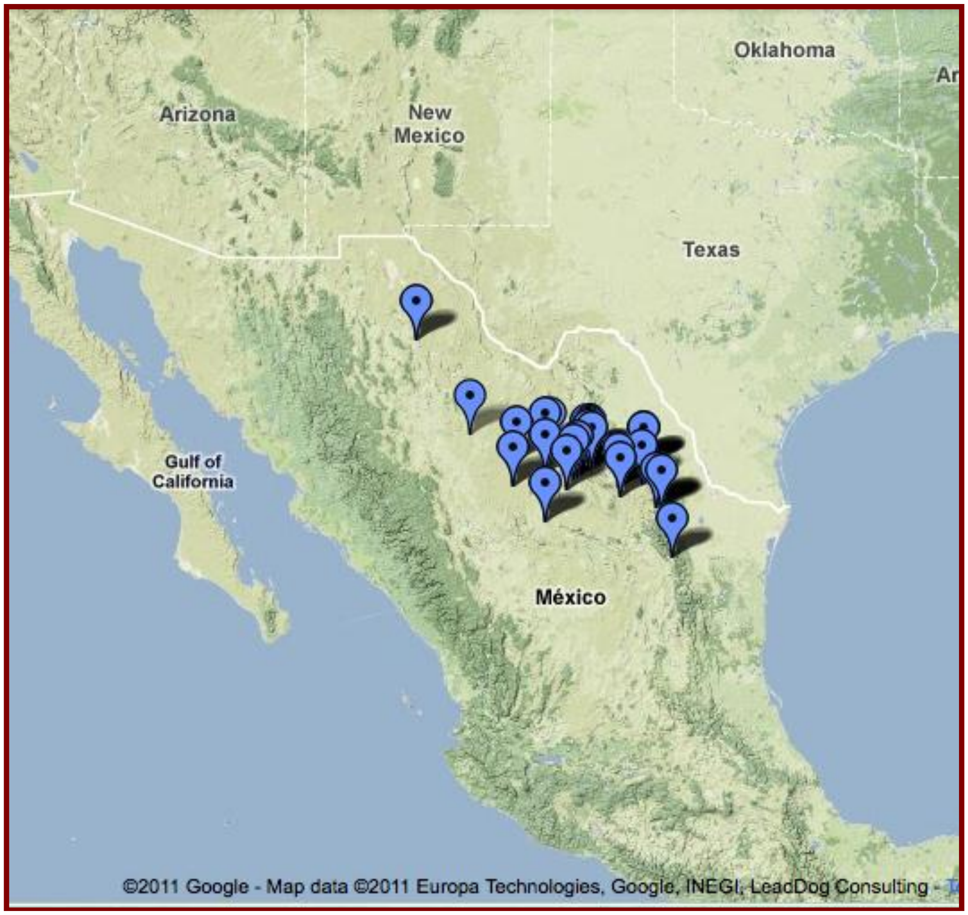


Figure 4.12: Geographic distribution of *Nama stenophylla.*

Appendix A. Thermocycler programs utilized to amplify molecular markers

Table A.1. Names of thermocycler programs utilized to amplify molecular markers.

Amplification Pairs	Thermocycler Programs
ITS M13F-M13R	CLONE, HSETS
ITSp1a-ITSp4	ETS, ITS-DJL, ITSSEJ, LINDER, NDHF1
matK1100F-trnK2R	ETS, MATKGEN, JMATK, JMK, NDHF, NDHF1, NDHF4
matK1F-matK1320R	JMATK, JMATKGEN, MATKGEN, MATKGENE, NDHF
matK1F-matK1408R	JMATK, NDHF1, NDHF5
matK1F-matK778R	JMATK,JMK, NDHF1, NDHF4
matK590F-matK1320R	JMATK, NDHF1, NDHF4, NDHF5
matK590F-trnK2R	JMATK, JMATKGEN, MATKGENE, NDHF
matK8F-trnK2R	JMATK, JMK, NDHF4, NDHF5
ndhF1F-ndhF722R	NDHF
ndhF1-ndhF722R	NDHF4
ndhF1704-ndhF2110R	NDHF4
ndhF1F-ndhF722R	NDHF1, NDHF5
ndhF1F-ndhF8	NDHF, NDHF2, NDHF4, NDHF5
ndhF3-ndhF8	JMNDHF, NDHF, NDHF1, NDHF4, NDHF5
ndhF7-ndhF2110R	NDHF, NDHF1
ndhF972Rep2-ndhF2110R	NDHF1, NDHF4

Table A.2. Thermocycler programs utilized in this study.

	Initial Denature			Denature		Anneal		Extension		Final Extension	
Program name	**temp (^oC)**	**time (min)**	**# cycles**	**temp (^oC)**	**time (s)**	**temp (^oC)**	**time (s)**	**temp (^oC)**	**time (s)**	**temp (^oC)**	**time (min)**
CLONE	94	10	25	94	60	55	60	72	60	72	7
ETS	95	1	29	94	30	50	30	72	90	72	7
HSETS	94	10	29	94	30	50	30	72	90	72	7
ITS-DJL	94	3	34	94	60	46	60	72	45 *	72	7
ITSSEJ	94	3	34	94	30	50	60	72	60	72	7
JMATK	94	4	34	94	30	49	60	72	60	72	6
JMATKGEN	94	2	34	94	60	51	60	72	60	72	6
JMK	94	3	29	94	30	45	30	72	90	72	2
JMNDHF	94	2	34	93	30	57	30	72	60	72	6
LINDER	94	1	29	94	30	50	30	72	90	72	7
MATKGEN	94	2	29	94	60	51	60	72	60	72	6
MATKGENE	94	2	34	94	60	48	60	72	60	72	6
NDHF	94	3	34	94	30	53**	30	72	60	72	6
NDHF1	94	3	34	94	30	50	60	68	60***	68	10
NDHF2	94	3	34	94	30	55	60	72	60	68	10
NDHF4	94	10	30	94	30	50	60	68	60	68	10
NDHF5	94	0.5	34	94	30	47	60	68	60	68	10
TERMIN8	96	1	25	96	10	50	5	60	240	72	7

* Final extension added 3s per cycle.
** First cycle only (following initial denaturation), annealing temperature was 50 ^oC for 1m.
*** First cycle only (following initial denaturation), extension time was 1m 20s

Appendix B. Maximum likelihood phylograms of the chloroplast, ITS, and combined data sets

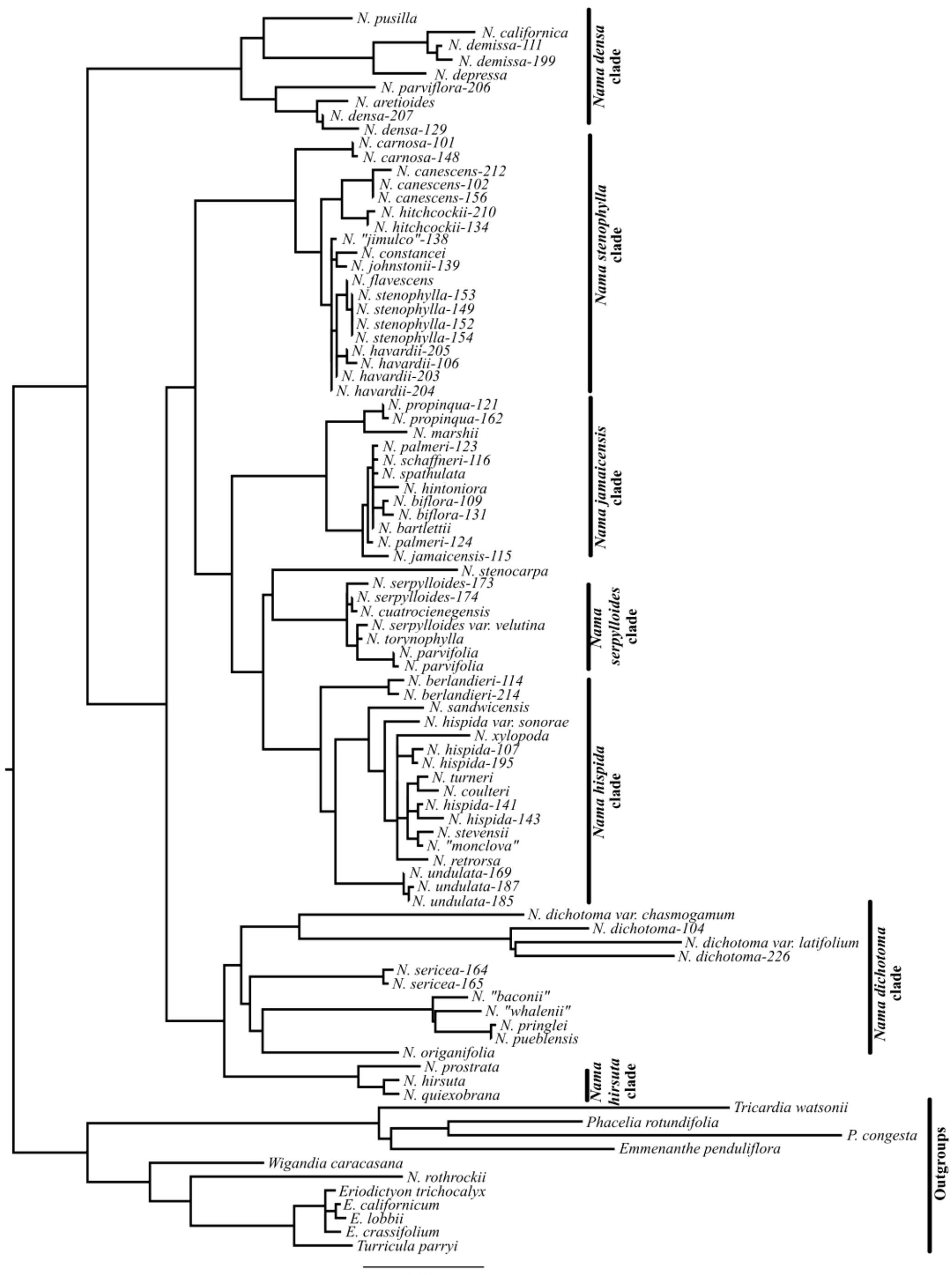


Figure A1. Phylogram of the best-scoring maximum likelihood phylogeny of the chloroplast data set recovered by RAxML. Bootstrap and Bayesian branch support values available in Figure 2.7.

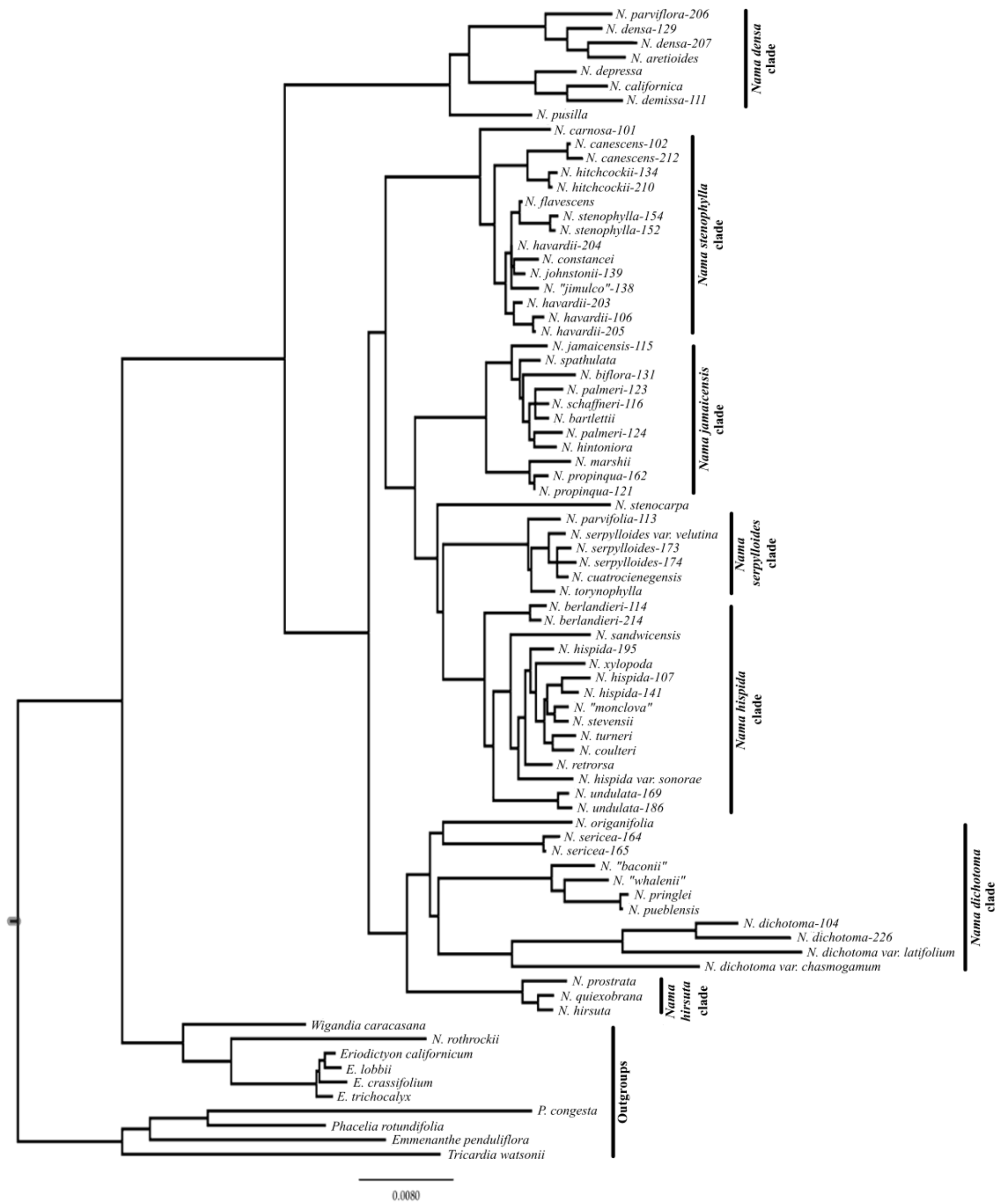


Figure A2. Phylogram of the best-scoring maximum likelihood phylogeny of the combined chloroplast + ITS data set recovered by GARLI. Bootstrap and Bayesian branch support values available in Figure 2.9.

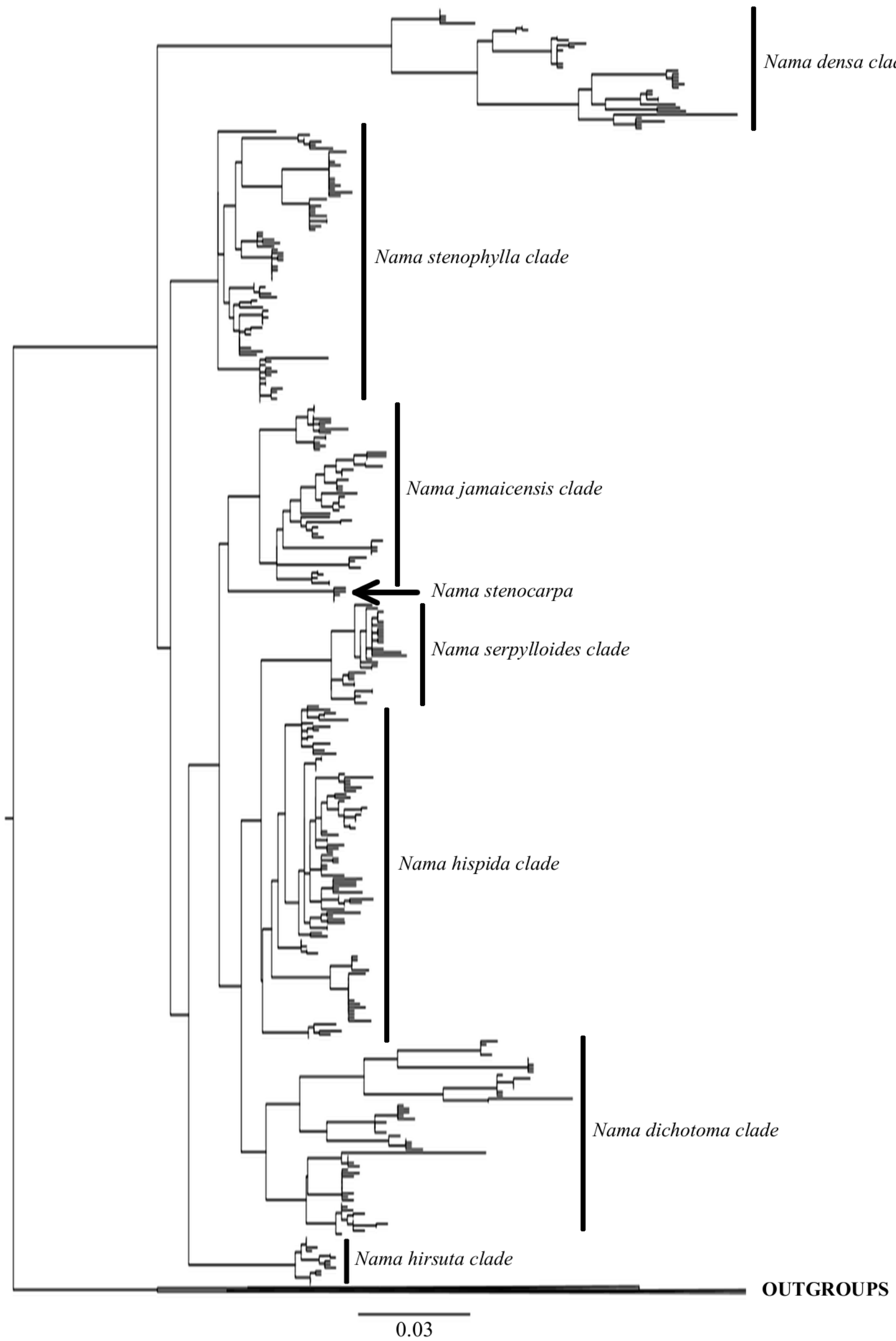


Figure A3. Phylogram of the best-scoring maximum likelihood phylogeny of the ITS data set recovered by RAxML. Bootstrap and Bayesian branch support values available in Figure 2.6C.

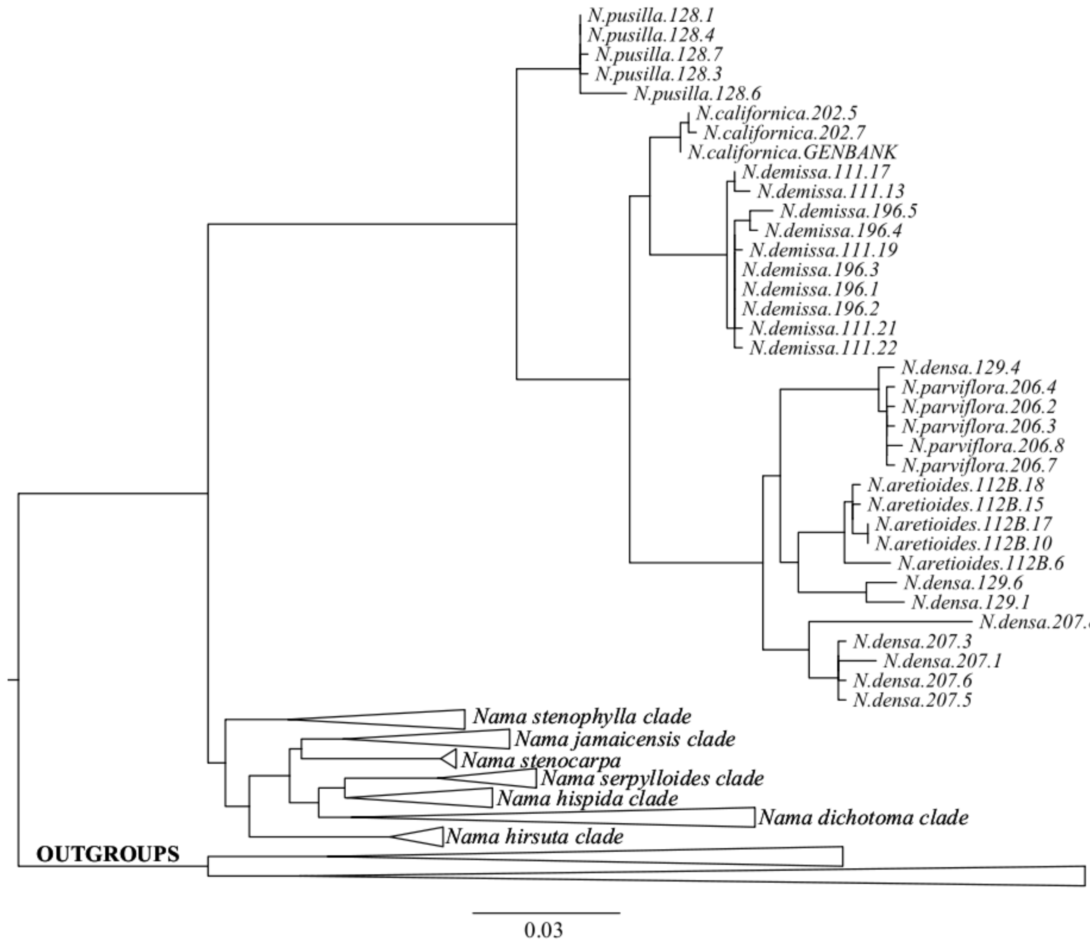


Figure A4. Phylogram of the best-scoring maximum likelihood phylogeny of the *Nama densa* lineage recovered by RAxML analysis of the ITS data set. Bootstrap and Bayesian branch support values available in Figure 2.8.

Figure A5. Phylogram of the best-scoring maximum likelihood phylogeny of the *Nama stenophylla* lineage recovered by RAxML analysis of the ITS data set. Bootstrap and Bayesian branch support values available in Figure 2.10.

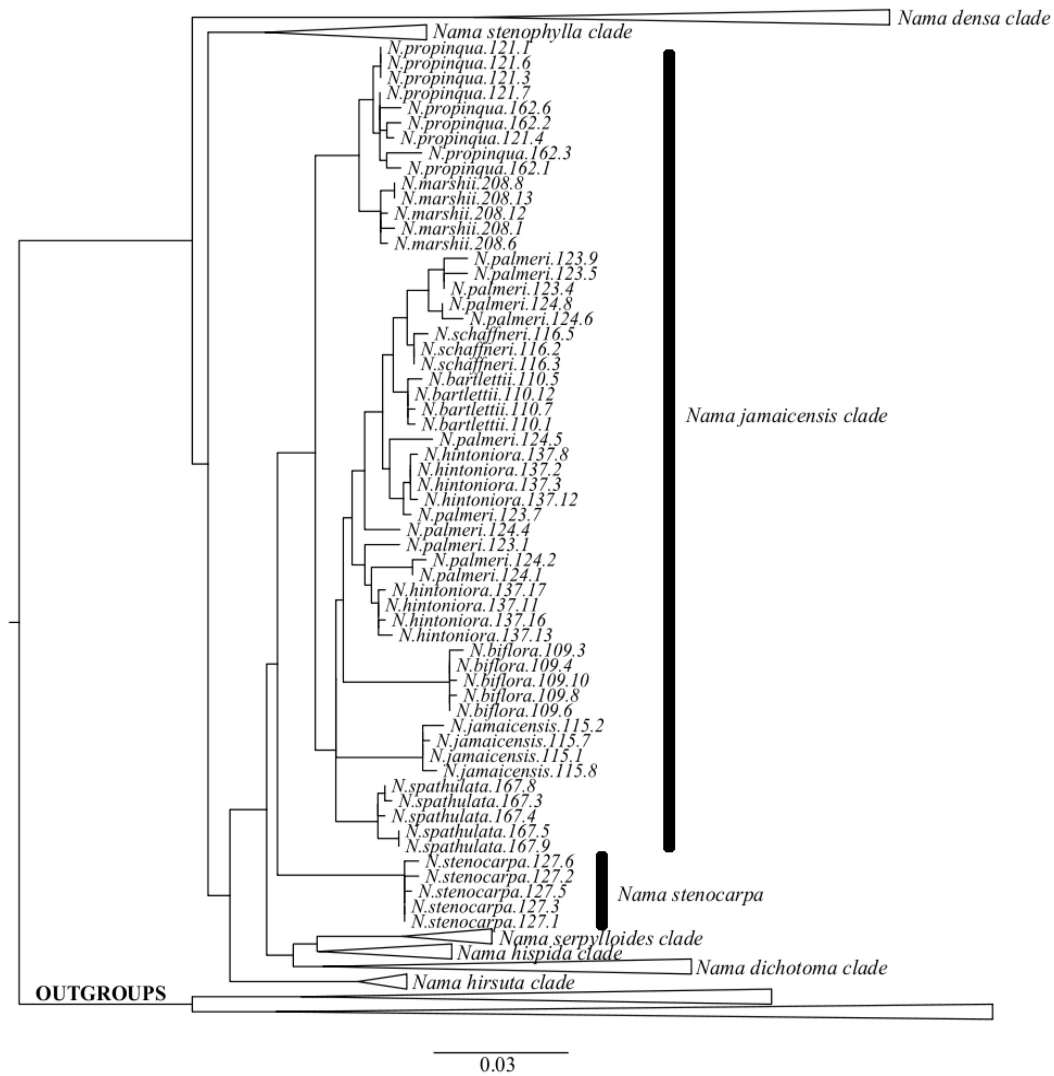


Figure A6. Phylogram of the best-scoring maximum likelihood phylogeny of the *Nama jamaicensis* lineage and *N. stenocarpa* recovered by RAxML analysis of the ITS data set. Bootstrap and Bayesian branch support values available in Figure 2.11.

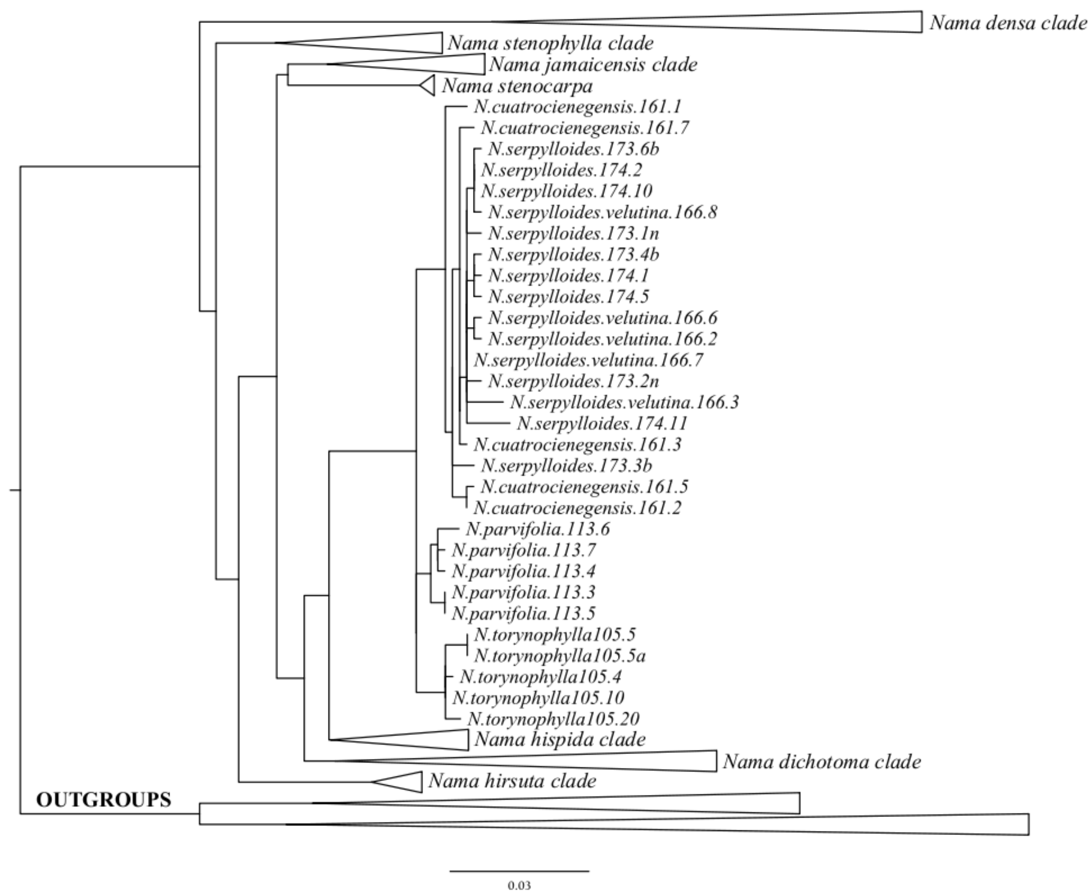


Figure A7. Phylogram of the best-scoring maximum likelihood phylogeny of the *Nama serpylloides* lineage recovered by RAxML analysis of the ITS data set. Bootstrap and Bayesian branch support values available in Figure 2.12.

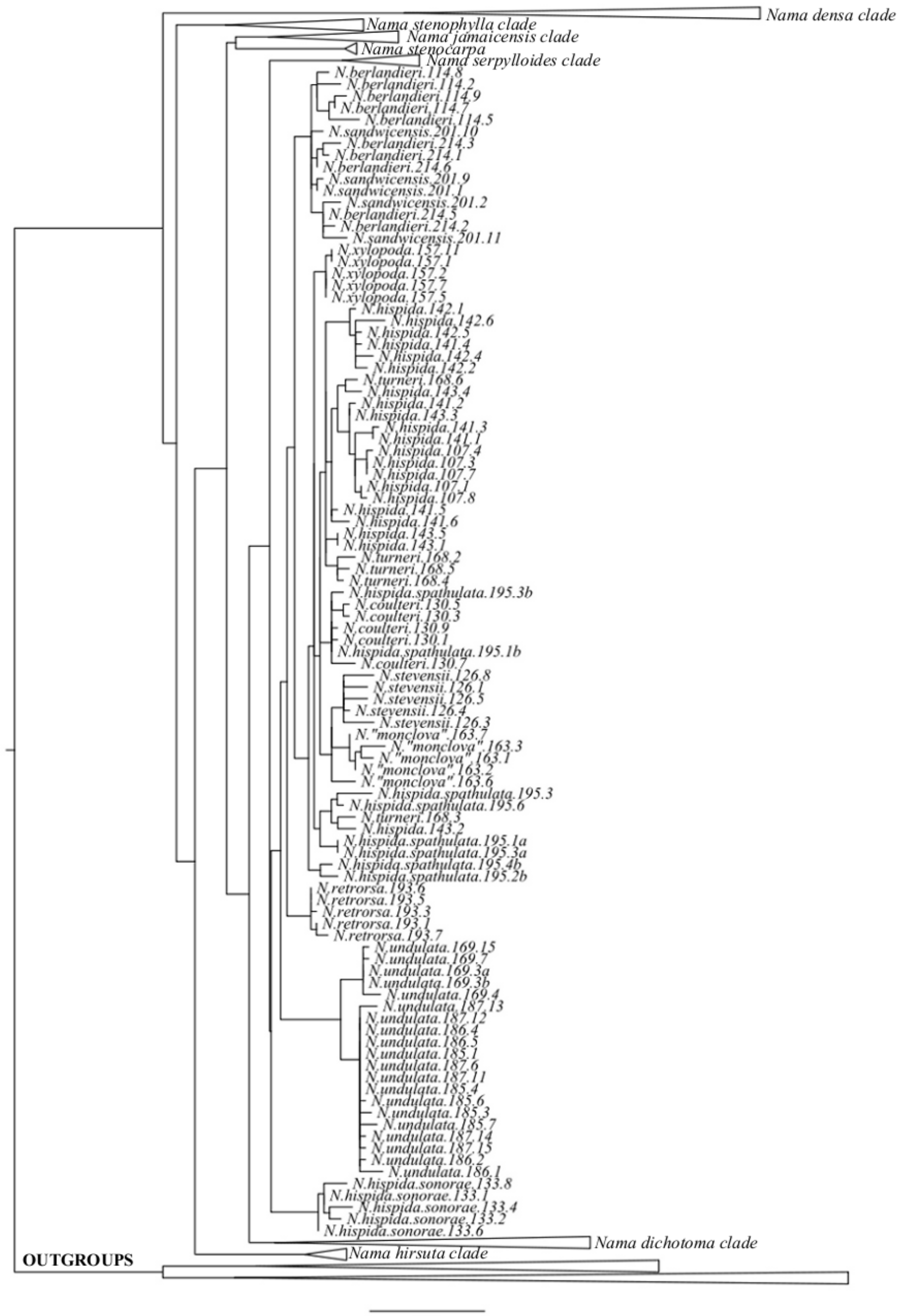


Figure A8. Phylogram of the best-scoring maximum likelihood phylogeny of the *Nama hispida* lineage recovered by RAxML analysis of the ITS data set. Bootstrap and Bayesian branch support values available in Figure 2.13.

Figure A9. Phylogram of the best-scoring maximum likelihood phylogeny of the *Nama dichotoma* and *Nama hirsuta* lineages recovered by RAxML analysis of the ITS data set. Bootstrap and Bayesian branch support values available in Figures 2.14 and 2.15.

Appendix C. Collection and locality data for 2099 specimens of *Nama* from LL, TEX, GH, MO, NY, RSA, US.

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
aretioides	aretioides	GH	A.Nelson/1118	15 Jul 1911	USA	ID	Elmore				
aretioides	aretioides	GH	J.F.Macbride/866	22 May 1911	USA	ID	Canyon				
aretioides	aretioides	GH	W.H.Shockley/226	11 Jun 1882	USA	NV					
aretioides	aretioides	GH	W.H.Shockley/226	s.d.	USA	NV					
aretioides	aretioides	GH	B.Maguire/25403	12 Jun 1945	USA	NV	Lander				
aretioides	aretioides	GH	B.Maguire/25441	15 Jun 1945	USA	NV	Nye				
aretioides	aretioides	GH	A.M.Alexander/4623	1 Jun 1946	USA	NV	Pershing				
aretioides	aretioides	GH	J.B.Leiberg/2016	6 May 1896	USA	OR	Matheur				
aretioides	aretioides	GH	A.Cronquist/7826	13 Jun 1955	USA	OR	Malheur				
aretioides	aretioides	GH	S.E.Greyn./s.n.	s.d.	USA						
aretioides	californica	GH	H.N.Bolander/s.n.	1872	USA	CA					
aretioides	californica	GH	C.L.Anderson/114	1865	USA	NV					
aretioides	multiflora	TEX	S.C.Tucker/3728	29 Apr 1954	USA	CA	Inyo				
aretioides	multiflora	TEX	S.C.Tucker/3728	29 Apr 1954	USA	CA	Inyo	east side of US 395, 100 yards from road, 10 mi north of Independence			
aretioides	multiflora	GH	C.A.Purpus/5029	Apr-Sep 1897	USA	CA					
aretioides	multiflora	GH	A.A.Heller/8286	18 May 1906	USA	CA	Inyo	Foothills west of Bishop			
aretioides	multiflora	GH	Torrey/s.n.	1865	USA	CA					
aretioides	multiflora	GH	J.G.Lemmon/1836	1875	USA	NV					
aretioides	multiflora	GH	J.Torrey/321	1865	USA	NV					
aretioides	multiflora	GH	A.M.Alexander/5311	9 Jun 1947	USA	NV	Lyon				
aretioides	multiflora	GH	L.E.Mills/8	7 Jun 1949	USA	NV	Churchill	Fairview, 2 mi east of Frenchman Station on US highway no. 50			

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
aretioides	multiflora	GH	A.Cronquist/9848	12 May 1963	USA	NV	Washoe	Sandy benchland overlooking the Truckee River, 1 mi northwest of Nixon; Twp. 23 S., R. 23 E.	1200		
aretioides	multiflora	GH	A.Cronquist/9848	12 May 1963	USA	NV	Washoe				
aretioides	multiflora	GH	J.M.G./s.n.	May 1874	USA						
aretioides	nevadensis	GH	C.F.Baker/1025	7 Jun 1902	USA	NV	Ormsby	Eagle Valley	1446		
aretioides		TEX	J.D.Morefield/3476 (dupl. n)	20 Apr 1986	USA	CA	Mono				
aretioides		TEX	J.D.Morefield/3476 (dupl. n)	20 Apr 1986	USA	CA	Mono	Low hills S of Rock Creek drainage, 0.1 mi NE of the SW corner of Sec. 36, T2S R32E.	1670		
aretioides		TEX	J.D.Morefield/3583 (dupl. n)	5 May 1986	USA	CA	Inyo				
aretioides		GH	Jalmie?/								
argentea		GH	C.A.Purpus/1401	Sep 1905	Mex.	HID		Ixmiquilpan			
baconii		LL	C.H.Ramos A./78	1967	Mex.	VER	ND	Cerro cerca del pueblo de El Lim?n		17.790	-94.100
baconii		TEX	B.L.Turner/15418	1983	Mex.	VER	PEROTE	2 mi SW of Totalco on E slope of rocky limestone ridge		19.467	-97.367
bartlettii		TEX	G.Nesom/6052	1987	Mex.	SLP	SANTO DOMINGO	Sa de San Carlos ca 5 mi S of San Carlos N side of Bufa El Diente		23.456	-101.230
bartlettii		GH	H.H.Bartlett/10745	1 Aug 1930	Mex.	TAM		La Morita; vicinity of Marmolejo	520		
bartlettii		GH	H.H.Bartlett/10960	15 Aug 1930	Mex.	TAM					

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
bartlettii		TEX	J.Crutchfield/5002B	1959	Mex.	TAM	SAN CARLOS	3 mi S of San Carlos		24.560	-98.911
berlanderi		TEX	W.R.Carr/135422	4/29/94		TX	Starr	"Lower Rio Grande Valley National Wildlife Reuge, Los Olmos Tract; ca. 100 ft S of boundary line at N edge of tract, ca. 4.7 airmiles N to NNE of jct. US Rt. 83 and F.M. 755 in Rio Grande City. Rio Grande City North Quadrangle. Elev. 300-320 ft."		26.441	97.222
berlanderi		TEX	J.T.Painter/14420	2/29/44		TX	Hidalgo	Sandy upland 23 miles north of Edenburgh.			
berlanderi		TEX	M.C.Johnston/3785	4/30/59		TX	Zapata	25 miles south-southeast of Zapata.			
berlanderi		TEX	R.Runyon/651	6/1/24		TX	CAMERON	"La Feria, Texas. Altitude 40."			
berlandieri		TEX	M.Dom?nguez M./8240	1962	Mex.	TAM	NUEVO LAREDO	Monterrey Hwy 65 Km S of Nuevo Laredo		26.955	-99.782
berlandieri		LL	J.R.Crutchfield/1134	3/16/66		TX	Hidalgo	Bentsen-Rio Grande Valley State Park.			

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
berlandieri		TEX	W.R.Carr/13423	3/29/94		TX	Starr	"Lower Rio Grande Valley National Wildlife Refuge, Los Olmos Tract; ca. 100 ft. S of boundary line at N edge of tract, ca. 4.7 airmiles N to NNE of jct. US Rt. 83 and F. M. 755 in Rio Grande City. Rio Grande City North Quadrangle. Elev. 300-320 ft."		26.441	97.222
berlandieri		TEX	R.Runyon/2530	4/13/41		TX	Hidalgo	San Juan. Altitude: 50 meters.			
berlandieri		TEX	R.Runyon/2550	4/13/41		TX	Hidalgo	Hidalgo and Starr Counties.			
berlandieri		TEX	B.C.Tharp/48-77	12/5/48		TX	Starr	"Los Olmos Creek, along highway just outside Rio Grande City."			
berlandieri		TEX	A.D.Wood/570A	2/21/64		TX	Starr	Hills east of Rio Grande City.			
berlandieri		TEX	Mrs. E.J.Walker/6	2/2/42		TX	Hidalgo	La Joya.			
berlandieri		TEX	A.D.Wood/832	3/22/68		TX	Starr	Starr County.			
berlandieri		LL	C.L.Lundell/9799	3/30/41		TX	Hidalgo	"Off U. S. 83, west of Mission."			
berlandieri		TEX	R.Runyon/s.n.	12/25/25		TX	Starr	"Riogrande, Texas. Altitude: 200 ft."			
berlandieri		TEX	Mrs. E.J.Walker/s.n.	2/9/42		TX	Hidalgo	"La Joya, Texas."			
berlandieri		LL	Mrs. E.J.Walker/s.n.	2/9/42		TX	Hidalgo	La Joya.			
berlandieri		GH	Berlandier/699	1869-70							
biflora	marshii	TEX-	E.G.Marsh Jr./	1936	Mex.	COA	M?ZQUIZ	Mariposa La Ranch		28.151	-101.754

Species	Variety	Herb type	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
biflora		GH	H.E.Moore, Jr./3745	7 Jul 1948	Mex.	HID					
biflora		TEX	W.M.Thompson/286	1958	Mex.	NL	SANTIAGO	Salto de Agua Cola de Caballo.		25.365	-100.163
biflora		LL	H.M.Parker/517	1971	Mex.	NL	SAN PEDRO GARZA GARC?A	Mesa de Chipinque.		25.613	-100.356
biflora		TEX	B.C.Tharp/1814	1923	Mex.	NL	MONTERREY	Ciudad Monterrey		25.671	-100.308
biflora		TEX	M.H.Mayfield/1890	1994	Mex.	NL	SANTIAGO	Along the Cola de Caballo/Laguna Sßnchez rd into high Sa SE of Monterrey; between Puerto Genovevo and La Ci?nega ca 1.5 to 2.5 air Km NW of Pto. Genovevo		25.383	-100.300
biflora		TEX	M.H.Mayfield/1923	1994	Mex.	NL	BUSTAMANTE	Along switchbacks of rd below the Grutas de Bustamante; from opening of cave to ca 4 rd Km below cave		26.500	-100.522
biflora		TEX	J.A.Villarreal/2759	1984	Mex.	NL	SANTIAGO	Areas cercanas Cola de Caballo (Nuevo Leon - SANTIAGO)		25.383	-100.167
biflora		TEX	G.L.Webster/2882	1948	Mex.	NL	SANTIAGO	Cola de Caballo (Nuevo Leon - SANTIAGO)		25.365	-100.163
biflora		TEX	R.C.Rollins/5855	1958	Mex.	NL	MONTERREY	Parque Chipinque.		25.601	-100.323
biflora		TEX	T.F.Patterson/6340	1988	Mex.	NL	MONTEMORELOS	La Trinidad (Nuevo Leon - MONTEMORELOS)		25.231	-100.089
biflora		TEX	F.W.Gould/6348	1952	Mex.	NL	AN?HUAC	Chipinque on Sa Anßhuac		25.613	-100.356

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
biflora		TEX	T.F.Patterson/6594	1988	Mex.	NL	BUSTAMANTE	Sa Gomas Bustamante Canyon N expoSure		26.550	-100.550
biflora		TEX	T.F.Patterson/6605	1988	Mex.	NL	BUSTAMANTE	Sa Gomas Bustamante Canyon (Nuevo Leon - BUSTAMANTE)		26.550	-100.550
biflora		TEX	T.F.Patterson/7091	1992	Mex.	NL	Montemorelos	Anacuitas (Adjuntas de Ballesteros).		25.282	-99.933
biflora		TEX	F.A.Barkley/7138	1947	Mex.	NL	ND	Centro Recreativo Chipinque. (Nuevo Leon - ND)		25.608	-100.356
biflora		TEX	T.F.Patterson/7399	1993	Mex.	NL	ND	Sa Gomas along the rd into Canyon El Alamo		26.367	-100.433
biflora		LL	R.L.Crockett/8062	1946	Mex.	NL	SANTIAGO	Salto de Agua Cola de Caballo.		25.365	-100.163
biflora		LL	R.L.Crockett/8069	1946	Mex.	NL	SANTIAGO	Salto de Agua Cola de Caballo.		25.365	-100.163
biflora		TEX	R.D.Worthington/8418	1982	Mex.	NL	ND	1 rd mi W of entrance to Cola de Caballo Hotel		25.350	-100.200
biflora		TEX	G.B.Hinton/17964	1980	Mex.	NL	ITURBIDE	La Mentira (Las Anacuas).		24.546	-99.823
biflora		TEX	G.B.Hinton/24119	1994	Mex.	NL	GALEANA	Guerrero.		25.188	-100.708
biflora		TEX	G.B.Hinton/24420	1994	Mex.	NL	GALEANA	Guerrero.		25.188	-100.708
biflora		TEX	R.Sanders/76068	1976	Mex.	NL	SANTIAGO	Salto de Agua Cola De Caballo.		25.365	-100.163
biflora		GH	C.H.Mueller/112	5 Jul 1933	Mex.	NL					
biflora		GH	S.S.White/1410	21 Jun 1939	Mex.	NL					
biflora		TEX	F.A.Barkley/14565-A	1944	Mex.	NL	ARAMBERRI	Ojo de Agua. (Nuevo Leon - ARAMBERRI)		24.388	-99.683
biflora		GH	F.A.Barkley/14565A	14 Aug	Mex.	NL					

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				1944							
biflora		NY	F.A.Barkley/14565A	14 Aug 1944	Mex.	NL		On a sunny bank of creek running from Ojo de Aqua to Parque de San Francisco near Villa de Santiago.			
biflora		NY	J.C.Johnson/15105 M	26 Feb 1946	Mex.	NL		On cliff near entrance to grotto. Limestone soil of Canon Huajuco, east of Villa Santiago, in the valley of Rio San Juan.			
biflora		US	S.S.White/1515	26 Jun 1939	Mex.	NL		Hacienda Vista Hermosa, 35 miles south of Monterrey	732		
biflora		GH	S.S.White/1515	26 Jun 1939	Mex.	NL					
biflora		TEX	R.Salinasey/16-M-381	1946	Mex.	NL	SANTIAGO	Cola de Caballo cerca de.		25.374	-100.160
biflora		TEX	C.A.Lind/16-M-578	1946	Mex.	NL	SANTIAGO	Cola de Caballo cerca de.		25.374	-100.160
biflora		GH	F.A.Barkley/16105M	26 Feb 1946	Mex.	NL					
biflora		TEX	J.C.Johnson/16135-M	1946	Mex.	NL	SANTIAGO	Ca±?n El Huajuco.		25.465	-100.165
biflora		US	F.W.Pennell/16841	19 Jun 1934	Mex.	NL		El diente canyon, Sierra Madre Oriental, south of Monterrey, 800-1100m elevation	800		
biflora		US	F.W.Pennell/16878	19 Jun 1934	Mex.	NL		El Diente Canyon, Sierra Madre Oriental, South of Monterrey	1200		
biflora		GH	G.B.Hinton/16929	27 Nov 1949	Mex.	NL					

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biflora		GH	W.C.Leavenworth/171	21 Jun 1940	Mex.	NL					
biflora		NY	D.S.Correll/19954	21 Jul 1958	Mex.	NL		On slope of ravine in open pine-oak forest of north-facing canyon, about 1.5 miles southwest of Pablillo			
biflora		GH	C.G.Pringle/2206	6 Jun 1888	Mex.	NL					
biflora		NY	G.B.Hinton/24119	12 May 1994	Mex.	NL		Puerto Guerrero, below.	865		
biflora		NY	G.B.Hinton/24420	16 Jun 1994	Mex.	NL	Santiago	Puerto Guerrero. Streambed in oak woods.	1105		
biflora		GH	H.E.Moore, Jr./3623	28 Jun 1948	Mex.	NL					
biflora		NY	R.C.Rollins/5855	16 Nov 1958	Mex.	NL		Chipinque Mesa, southwest of Monterrey	1100		
biflora		GH	W.C.Leavenworth/73	15 Jun 1940	Mex.	NL					
biflora		NY	V.H.Chase/7781	8 Aug 1939	Mex.	NL	Santiago	Wooded ravine, Horse Tail Falls			
biflora		GH	V.H.Chase/778I	8 Aug 1939	Mex.	NL	Santiago				
biflora		TEX	J.L.Neff/92-3-22-4	1992	Mex.	NL	SANTIAGO	Cola de Caballo 7 Km al W.		25.354	-100.187
biflora		NY	E.Palmer/985	17-26 Feb 1880	Mex.	NL		Monterey			
biflora		TEX	R.Ford S./M-44	1960	Mex.	NL	SANTIAGO	Ca±?n La Boca.		25.428	-100.115
biflora		TEX	L.I.Davis/SN	1946	Mex.	NL	MONTERREY	Ciudad Monterrey cerca de.		25.671	-100.308
biflora		US	Rzedowski/27741	17 Sep 1970	Mex.	QUE		4 km al SW de Ahuacatlan, municipio de Pinal de Amoles.	2150		

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biflora		NY	Rzedowski/27741	17 Sep 1970	Mex.	QUE	Pinal de Amoles	4 km al SW de Ahuacatlan. Ladera pizarrosa con vegetacion de matorral secondario.	1250		
biflora		TEX	J.B.Alcorn/2064	1978	Mex.	SLP	SAN ANTONIO	Between Tanjasnec and San Pedro		21.650	-98.864
biflora		TEX	M.C.Carlson/2751	1954	Mex.	SLP	ND	Colonia Salto del Agua		22.581	-99.404
biflora		TEX	J.B.Alcorn/3064	1979	Mex.	SLP	AQUISM?N	Mantezulel		21.628	-99.054
biflora		TEX	R.M.King/3880	1961	Mex.	SLP	ND	Colonia Salto del Agua		22.581	-99.404
biflora		TEX	J.Crutchfield/5117	1960	Mex.	SLP	NARANJO EL	Colonia El Meco		22.571	-99.342
biflora		TEX	G.Nesom/6047	1987	Mex.	SLP	SANTO DOMINGO	Sa de San Carlos ca 5 mi S of San Carlos N side of Bufa El Diente		23.456	-101.230
biflora		TEX	G.Nesom/6272	1988	Mex.	SLP	SANTO DOMINGO	Sa de San Carlos ca 5 mi S of San Carlos N side of Bufa El Diente		23.456	-101.230
biflora		US	F.W.Pennell/17961	7 Aug 1934	Mex.	SLP		Espinazo del Diablo, Tamasopo Canyon, Sierra Madre Oriental	800		
biflora		GH	F.W.Pennell/17961	7 Aug 1934	Mex.	SLP					
biflora		NY	F.W.Pennell/17961	7 Aug 1934	Mex.	SLP		Espinazo del Diablo, Tamasopo Canyon, Sierra Madre Oriental. Rocky limestone woods	800		
biflora		NY	E.Palmer/23	2-8 Jun 1904	Mex.	SLP		Rio Verde			
biflora		USA	F.R.Fosberg/29460	21 Dec 1947	Mex.	SLP		Rio Naranjo at foot of upper falls of El Salto	600	22.667	98.667
biflora		GH	F.R.Fosberg/29460	21 Dec	Mex.	SLP					

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				1947							
biflora		NY	F.R.Fosberg/29460	21 Dec 1947	Mex.	SLP		Rio Naranjo at foot of upper falls of El Salto	600	22.667	98.667
biflora		NY	R.M.King/3880	20 Feb 1961	Mex.	SLP		Near the waterfall at El Salto			
biflora		GH	Kenoyer/4034	2 Sep 1948	Mex.	SLP					
biflora		GH	C.C.Parry/702 1/2	1878	Mex.	SLP					
biflora		NY	D.B.Ward/7782	29 May 1971	Mex.	SLP		Dry film of soil on uppermost Surfaces of rocks above plunge basin of El Salto Falls, Rio Valles, ca. 20 mi. (air line) n.e. of Ciudad del Maiz	500		
biflora		TEX	F.S.Webster/23	1964	Mex.	TAM	ND	Sa de Guatemala		23.083	-99.250
biflora		TEX	A.Richardson/323	1968	Mex.	TAM	GOMEZ FARAS	El Cielo.		23.099	-99.192
biflora		TEX	A.Richardson/384	1968	Mex.	TAM	GOMEZ FARAS	Between Indian Springs and Agua Linda turnoff		23.099	-99.191
biflora		TEX	A.Richardson/433	1968	Mex.	TAM	GOMEZ FARAS	Between Indian Springs and Agua Linda turnoff		23.099	-99.191
biflora		TEX	A.Richardson/503	1968	Mex.	TAM	GOMEZ FARAS	Rancho del Cielo mine rd		23.099	-99.191
biflora		TEX	R.Runyon/753	1925	Mex.	TAM	VICTORIA	Ciudad Victoria.		23.736	-99.146
biflora		TEX	R.Runyon/914	1926	Mex.	TAM	VICTORIA	Ciudad Victoria.		23.736	-99.146
biflora		TEX	R.Runyon/962	1926	Mex.	TAM	VICTORIA	Ciudad Victoria cerca de.		23.736	-99.146
biflora		TEX	L.Hernßndez/1318	1984	Mex.	TAM	SAN CARLOS	Cerro El Diente. Sa de San Carlos. 17 Km al SW de San Carlos (Tamaulipas - SAN CARLOS)		23.300	-98.250

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biflora		TEX	L.Hernßndez/2261	1988	Mex.	TAM	ALDAMA	Cerro El Diente ladera ENE.		23.278	-98.107
biflora		TEX	R.M.King/4073	1961	Mex.	TAM	ALTAMIRA	2 mi NE of Altamira		22.404	-97.909
biflora		TEX	R.M.King/4519	1961	Mex.	TAM	VICTORIA	Ciudad Victoria 8 mi al E Hwy 70.		23.717	-99.040
biflora		TEX	C.P.Cowan/5205	1985	Mex.	TAM	VICTORIA	Ciudad Victoria 17.6 Km al SW Hwy 101.		23.621	-99.212
biflora		TEX	G.Nesom/6324	1988	Mex.	TAM	Hidalgo	W of Santa Engracia into the Sa ca 35 Km W of railrd crossing in Adelaida		24.017	-99.567
biflora		TEX	T.F.Patterson/7325	1993	Mex.	TAM	ALDAMA	Los Cerritos NW; Sierra Tamaulipas en el camino al Cerr Borrado		23.207	-98.255
biflora		TEX	L.E.Brown/13388	1988	Mex.	TAM	MAINERO	Villa Mainero		24.560	-99.619
biflora		TEX	G.B.Hinton/24294	1994	Mex.	TAM	Hidalgo	Ca±on de Mimbres (Curvas del Huizache)		24.084	-99.429
biflora		TEX	G.B.Hinton/25026	1994	Mex.	TAM	Hidalgo	Ca±?n de Mimbres (Curvas del Huizache).		24.084	-99.429
biflora		TEX	G.B.Hinton/25038	1994	Mex.	TAM	Hidalgo	Miradores (Tamaulipas - Hidalgo)		24.047	-99.314
biflora		TEX	G.B.Hinton/25149	1994	Mex.	TAM	JAUMAVE	Chihue (Arroyo)		23.842	-99.483
biflora		TEX	G.B.Hinton/25263	1995	Mex.	TAM	Hidalgo	Purificaci?n (Tamaulipas - Hidalgo)		24.152	-99.439
biflora		GH	L.R.Stanford/1051	22 Aug 1941	Mex.	TAM					
biflora		NY	L.R.Stanford/1051	22 Aug 1941	Mex.	TAM		10 kilo. Northwest of El Progresso which is 18 kilo. Northwest of Ocampo. On mountains with luxuriant vegetation	1450	23.000	98.500

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biflora		GH	H.H.Bartlett/10706	29 Jul 1930	Mex.	TAM					
biflora		US	H.H.Bartlett/10706	29 Jul 1930	Mex.	TAM		La Tamaulipica, Vicinity of San Miguel			
biflora		GH	H.H.Bartlett/11135	25 Aug 1930	Mex.	TAM					
biflora		US	H.H.Bartlett/11135	25 Aug 1930	Mex.	TAM		Cerro Zamora, vicinity of El Milagro, Sierra de San Carlos			
biflora		GH	R.L.Dressler/2023	25 Jul 1957	Mex.	TAM					
biflora		NY	G.B.Hinton/24294	5 Jun 1994	Mex.	TAM	Hidalgo	Los Mimbres. Bank in oak and pine forest.	1325		
biflora		NY	R.M.King/4073	3 Mar 1961	Mex.	TAM		Low shrub oak forests 2 miles northeast of Altamira			
biflora		NY	R.M.King/4519	7 Apr 1961	Mex.	TAM		Mountains along route 70, ca. 8 miles south of Ciudad Victoria.			
biflora		GH	E.Palmer/524	1 May to 13 Jun 1907	Mex.	TAM					
biflora		NY	E.Palmer/524	1 May to 13 Jun 1907	Mex.	TAM		Vicinity of Victoria	320		
biflora		NY	G.Nesom/6047	17 Jun 1987	Mex.	TAM	San Carlos	Sierra de San Carlos, ca. 5 mi S of San Carlos, N side of Bufa El Diente, igneous bedrock; N-facing steep slope	770	24.525	97.040
biflora		TEX	A.Chßvez/SN	1969	Mex.	TAM	GOMEZ FARAS	El Cielo.		23.099	-99.192
biflora		NY	G.B.Hinton/4604	28 Aug 1933	Mex.		Temascaltepec	Tejupilco	1340		

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biflora		NY	E.Palmer/702 1/2	Dec 1878 to Feb 1879	Mex.			En route from San Luis Potosi to Tampico			
biflora		US	R.Runyon/753	27 Mar 1925	Mex.			High upon mountain So. Of Victoria, N.E. Mexico	90		
biflora		US	R.Runyon/928	4 Apr 1926	Mex.			River bottom near Victoria Tamps	400		
biflora		US	R.Runyon/962	5 Apr 1926	Mex.			Base of mts near Victoria Tamp.	400		
biflora		GH	Berlandier/780 and 2200								
californica		LL	C.F.Smith/2000	May 1947	USA	CA	Ventura				
californica		MO	C.G.Parry/267	Apr 1876	USA	CA	San Bernardino	Mojave R. dist. San Bernardino Co. Calif.			
californica		RSA	P.A.Munz/13229	1 May 1934	USA	CA	Ventura	Sandy flats, upper Sespe Creek, north of Wheelers Hot Springs	1335		
californica		RSA	P.A.Munz/13361	21 May 1949	USA	CA	Kern	20 miles from Weldon onroad to Walker Pass in coarse gravel	1500		
californica		RSA	N.Fraga/1499	23 Feb 2005	USA	CA	Inyo	Mojave Desert; East Mojave Desert region: ON Ibex Spring Road just east of border with Death Valley National Park. (Ibex Pass USGS 7.5' Quadrangle)	427	35.764	115.659

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californica		RSA	R.F.Thorne/53340	3 Jul 1979	USA	CA	San Bernardino	San Bernardino Mountains: San Bernardino National Forest. Holcomb Creek and adjacent meadow androcky slopes just west of Hitchcock Ranch on 3N12	2385		
californica		RSA	L.C.Wheeler/6645	13 Jun 1948	USA	CA	Los Angeles	San Gabriel Mountains: Coldwater Canyon, off Big Tujunga.	1100		
californica		RSA	J.Roos/667	26 Jul 1937	USA	CA	San Bernardino	Bear Valley, near Pine Knot. San bernardino Mts.			
californica		RSA	R.F.Hoover/8209	24 May 1952	USA	CA	San Luis Obispo	Caliente Mt.			
californica		RSA	L.C.Wheeler/9473	12 May 1967	USA	CA	Los Angeles	San Gabriel Mts., Hunt Canyon 3 mi E of Vincent, gentle sunny easterly slope, granular loam	1200		
californica		RSA	M.E.Jones/s.n.	7 Jun 1926	USA	CA		South of Lebec.			
californica		RSA	L.C.Wheeler/s.n.	31 May 1969	USA	CA	Tulare	Sierra Nevada. Chimney Creek. East Chimney Creek Campground.	1900		
californica		TEX	I.W.Clokey/5918	7 Apr 1941	USA	NV	Clark				
californica		TEX	I.W.Clokey/5925	29 Apr 1941	USA	NV	Clark				
canescens		LL	C.Wells/515	1977	Mex.	NL	DOCTOR ARROYO	Cerro Pe±a Nevada lado NW		23.779	-99.870
canescens		TEX	J.D.Bacon/1121	1971	Mex.	NL	GALEANA	San Roberto 17 mi al S Hwy 57.		24.484	-100.308

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canescens		TEX	G.B.Hinton/2179	1991	Mex.	NL	GALEANA	La Poza 21.375 Km al SE carr a R?o de San Jos?.		24.580	-99.965
canescens		TEX	G.Nesom/4276	1981	Mex.	NL	DOCTOR ARROYO	San Antonio de Pe±a Nevada 2.5 Km al ENE.		23.751	-99.960
canescens		TEX	M.Lavin/4758	1984	Mex.	NL	GALEANA	San Roberto 15.2 mi al S Hwy 57.		24.504	-100.289
canescens		TEX	B.L.Turner/6229	1970	Mex.	NL	GALEANA	Entronque San Roberto 12.6 mi al E camino a Linares.		24.693	-100.116
canescens		TEX	G.Nesom/7450	1994	Mex.	NL	GALEANA	From a point ca halfway between La Boca del Refugio and San Pablo along the main rd ca 5 km N in an area of gypsum and limestone slopes		25.078	-100.475
canescens		TEX	B.L.Turner/15009	1980	Mex.	NL	GALEANA	Entronque San Roberto 18 mi al E.		24.728	-100.041
canescens		TEX	G.B.Hinton/20644	1990	Mex.	NL	ARAMBERRI	El Salero. (Nuevo Leon - ARAMBERRI)		24.334	-99.907
canescens		TEX	G.B.Hinton/21584	1991	Mex.	NL	GALEANA	R?o de San Jos? nr (Nuevo Leon - GALEANA)		24.597	-99.888
canescens		TEX	G.B.Hinton/22346	1992	Mex.	NL	ARAMBERRI	San Francisco de Leos		24.317	-99.720
canescens		TEX	G.B.Hinton/22571	1992	Mex.	NL	GENERAL ZARAGOZA	Entre General Zaragoza y El Salitre		23.971	-99.809

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canescens		TEX	G.B.Hinton/22657	2001	Mex.	NL	GALEANA	Ca 35 air mi SE of Saltillo 0.5 mi N of Navidad or 4.2 mi N of San Rafael along Hwy 57; a prairie dog town		25.078	-100.604
canescens		TEX	G.B.Hinton/23036	1993	Mex.	NL	ARAMBERRI	Sand?a (Sand?a El Grande) 22.55 Km al SW carr a Santa Gertrudis.		24.055	-100.112
canescens		TEX	G.B.Hinton/27650	2000	Mex.	NL	GALEANA	El Aguililla		24.970	-100.561
canescens		LL, TEX	G.B.Hinton/22312	19 Aug 1992	Mex.	NL	GALEANA	S.A. de Texas. (San Ignacio?)	1675	24.311	-100.188
canescens		LL, TEX	J.Henrickson/22657	26 Jun 2001	Mex.	NL		On open gypsum plains ca. 35 air miles SE of Saltillo, 0.5 miles N of Navidad, or 4.2 miles N of San Rafael along Hwy 57			
canescens		GH	W.E.Manning/53279	13 Jul 1953	Mex.	NL					
canescens		TEX	J.D.Bacon/1123	1971	Mex.	SLP	ND	Just W of Hwy 57 on rd to Cedral		23.697	-100.618
canescens		TEX	B.L.Turner/6212	1970	Mex.	SLP	ND	36 mi S of Matehuala at Village of Valljais		23.139	-100.516
canescens		TEX	J.S.Henrickson/6548	1971	Mex.	SLP	ND	3-5 mi N of Matehuala towards Cedral		23.700	-100.650
canescens		GH	I.M.Johnston/7510	10-11 Sep 1938	Mex.	SLP		38 miles south of Matehuala =			
canescens		GH	I.M.Johnston/7510	10-11 Sep 1938	Mex.	SLP		Road from San Luis Potosi to Matehuala (via Huizachal); 38 miles south of Matehuala			

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canescens		GH	I.M.Johnston/7584	11-12 Sep 1938	Mex.	SLP					
carnosa		TEX	M.C.Johnston/	1973	Mex.	CHI	ND	Sa del Roque N of Julimes N and NW of Rancho El Sauz		28.650	-105.300
carnosa		NY	D.S.Correll/9849	20 Jul 1958	Mex.	NL		about 3 mi south of Galeana			
carnosa		US	E.O.Wooton/164	17 Jul 1897	USA	NM	Dona Ana	on the White Sands, Dona Ana Co.	1333		
carnosa		RSA	E.O.Wooton/164	17 Jul 1897	USA	NM	Dona Ana	On the White Sands	1333		
carnosa		GH	F.Shreve/10250	6 Aug 1941	USA	NM	Eddy				
carnosa		TEX	B.L.Turner/15811	14 Jul 1988	USA	NM	Eddy				
carnosa		NY	L.C.Higgins/17505	7 Sep 1987	USA	NM	Eddy	Mile post 5 along Hwy 62-180 southwest of whites city	1300		
carnosa		GH	B.C.Tharp/19	21 Aug 1941	USA	NM					
carnosa		GH	A.L.Hershey/2632	27 Jun 1942	USA	NM	Eddy				
carnosa		NY	N.D.Atwood/28985	6 Sep 2002	USA	NM	Socorro	NNW of Lonnie Moon Peak	2226	33.833	105.750
carnosa		GH	V.L.Cory/33286	8 Sep 1939	USA	NM	Otero				
carnosa		TEX	B.L.Turner/5665A	22 May 1967	USA	NM	Culberson				
carnosa		NY	U.T.Waterfall/5740	9 Oct 1944	USA	NM	Eddy	3 mi N. of Texas State Line near US #62 (Hills extend north from Cluberson Plateau between Deleware (sic) Mts. And Rustler Hills.			

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carnosa		TEX	J.B.Secor/63	18 Aug 1967	USA	NM					
carnosa		TEX	B.L.Turner/6400	19 Jul 1972	USA	NM	Eddy				
carnosa		GH	W.A.Archer/7315	19 Oct 1938	USA	NM	Otero				
carnosa		NY	R.Spellenberg/8246	30 Aug 1985	USA	NM	Eddy	ca. 20 air miles S of Carlsbad, ca. 5 mi. SE Whites City. E Sec. 28, T25N, R26E	1100		
carnosa		NY	L.C.Higgins/8561	3 Jun 1974	USA	NM	Eddy	15 miles south of Whites City			
carnosa		NY	L.C.Higgins/9242	29 Aug 1974	USA	NM	Eddy	17 miles north of Carlsbad on hwy 285			
carnosa		TEX	B.L.Turner/93-9	30 May 1993	USA	NM	Eddy				
carnosa		NY	R.D.Worthington/12119	16 Jun 1984	USA	TX	Hudspeth	12.5 mi E Dell City			
carnosa		NY	R.D.Worthington/12547	9 Sep 1984	USA	TX	Hudspeth	12.5 mi. E Dell City			
carnosa		GH	D.S.Correll/18532	26 Jul 1957	USA	TX	Culberson				
carnosa		GH	D.S.Correll/19297	5 Jul 1958	USA	TX	Hudspeth				
carnosa		GH	B.L.Turner/210	16 Sep 1948	USA	TX	Culberson				
carnosa		GH	V.L.Cory/2291	17 Jun 1928	USA	TX	Culberson				
carnosa		NY	L.C.Hinckley/2584	15 Aug 1942	USA	TX	Hudspeth	near Malone section house NW. Sierra Blanca			
carnosa		NY	R.Spellenberg/3648	8 Sep 1973	USA	TX	Hudspeth	10 mi. NY of Sierra Blanca, along I-10; and SW end of Malone Mts.			
carnosa		GH	U.T.Waterfall/4475	12 Jun 1943	USA	TX	Culberson				

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carnosa		NY	U.T.Waterfall/5006	10 Jul 1943	USA	TX	Culberson	40 miles northeast of Van Horn			
carnosa		GH	U.T.Waterfall/5022	12 Jul 1943	USA	TX	Hudspeth				
carnosa		NY	U.T.Waterfall/5022	12 Jul 1943	USA	TX	Hudspeth	around gypsum quarry east of Finley			
carnosa		NY	L.C.Higgins/6851	21 May 1973	USA	TX	Culberson	26 miles east of hyw 62-180 along hwy 652			
carnosa		NY	T.Waterfall/	20 Jul 1943	USA	TX	Culberson	10 miles north of Daugherty			
carnosa		GH	L.C.Hinckley/2584	15 Aug 1942	USA						
carnosa		LL	B.H.Warnock/10272	10/7/51		TX	Culberson	Along pipeline between Texline and Orla. Alt. 3500 feet.			
carnosa		LL	D.S.Correll/18532	7/26/57		TX	Culberson	"Along route #1108, 8 miles north of Delaware Spring."			
carnosa		LL	D.S.Correll/19099	7/1/58		TX	Culberson	North side of Delaware Creek.			
carnosa		LL	D.S.Correll/19297	7/5/58		TX	Hudspeth	Southeast base of Malone Mts.			
carnosa		TEX	B.L.Turner/20-450	8/1/00		TX	Culberson	23.4 miles west of Reeves Co. line along highway 652.		31.900	103.600
carnosa		LL	B.H.Warnock/210	9/16/48		TX	Culberson	35 miles north of Van Horn. Alt. 4000 ft.			
carnosa		LL	A.M.Powell/2216	10/29/71		TX	Culberson	25 miles west of Orla.			
carnosa		LL	D.S.Correll/27953	6/20/63		TX	Culberson	2 miles southeast of State Line Cafe.			

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carnosa		TEX	E.J.Travis/51-13	8/20/50		TX	Culberson	30 miles NNE of Kent.			
carnosa		TEX	B.H.Warnock/6254	7/5/47		TX	Culberson	2 miles south of Texline pipeline highway to Orla.			
cf. biflora		GH	F.W.Pennell/16933	22 Jun 1934	Mex.	NL		Hacienda "Vista Hermosa" south of Villa Santiago, Sierra Madre Oriental	800		
constancei		LL	M.C.Johnston/10385 e	24 Mar 1973	Mex.	COA	ND	Ca 1 Km W of Las Delicias at and near spring top of alluvial fan on side of Mt	1200	26.233	-102.825
constancei		TEX	J.S.Henrickson/1157	8 Aug 1973	Mex.	COA	ND	Ca 62 (air) mi WSW of Cuatro Ci?negas in long winding limestone canyon in N side of the Sa de Organos	1800	26.683	-103.050
constancei		TEX	M.C.Johnston/12112	8 Aug 1973	Mex.	COA	ND	S part of Sa de Los Organos approach 9.5 Km E of Puerto del Gallo then by foot S into large canyon	1700	26.725	-103.017
constancei		TEX-type	J.Henrickson/12113	8 Aug 1973	Mex.	COA	ND	Ca 62 (air) mi WSW of Cuatro Cienegas on N side of Sa de la Organos about 5 air mi SW of Cuesta de Gallo		26.733	-103.050

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constancei		TEX	J.S.Henrickson/12248	12 Aug 1973	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 72 (air) mi SW of on E side of Sierra de las Delicias around spring 1.5 mi SW of Las Delicias.(Ca.)	1250	26.200	-102.841
constancei		TEX	J.S.Henrickson/13714	30 Sep 1973	Mex.	COA	ND	Ca 18 (air) mi NE of Tlahualilo in Sa de Tlahualilo ca 9 (air) mi NW of Los Charcos de Risa Laguna del Rey (Quimicas del Rey)	1500	26.283	-103.233
constancei		TEX	J.S.Henrickson/20530 3	25 Sep 1998	Mex.	COA	OCAMPO	Ca 31. 5 rd mi S of on the paved rd S to San Pedro de las Colonias	1100	26.700	-103.167
constancei		TEX	J.S.Henrickson/22198	5 Oct 1997	Mex.	COA	ND	Ca 75 air mi SW of Cuatro Cienegas near N end of Puerto de Ventanillas in S Sa Las Delicias at new Strontium mine in Sa La Caldelaria E of Hwy	1080	26.083	-102.700
constancei		TEX	J.S.Henrickson/22617	20 Sep 1999	Mex.	COA	ND	N end of Valley of Acatita 15. 1 rds mi N of Rancho Acatita where NE-SW runing spur (Sa del Cuchilla) extends to Hwy	1150	26.650	-103.167

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constancei		LL, TEX	J.Henrickson/23112	16 Oct 2002	Mex.	COA		+/- 2 miles SW of town of Los Delicias above and around the spring (Agua Grande) that flows from the Sierra de Delicias above the town.	950	26.800	101.800
constancei		GH	R.M.Stewart/2752	25 Sep 1942	Mex.	COA					
constancei		GH	R.M.Stewart/2754	25 Sep 1942	Mex.	COA					
constancei		GH	R.M.Stewart/2814	2 Oct 1942	Mex.	COA					
constancei		TEX	J.S.Henrickson/6036	27 Aug 1971	Mex.	COA	SAN PEDRO	Ca 32 (air) mi NE of San Pedro 1 mi SW of Las Delicias (Coahuila - SAN PEDRO)	1200	26.233	-102.817
constancei		LL, TEX	J.Henrickson/6036	27 Aug 1971	Mex.	COA		ca 32 (air) miles NE of San Pedro,1 mile SW of Las Delicias at spring on limestone cliffs.	1200	26.233	101.183
constancei		LL	F.Chiang C/9508b	24 Sep 1972	Mex.	COA	ND	12 Km NNE of Las Margaritas on the E-most ridge of the Sa de las Margaritas	1350	26.558	-102.858
constancei		TEX	J.S.Henrickson/12211	9 Aug 1973	Mex.	DUR	TLAHUALILO	Tlahualilo de Zaragoza 32 mi ca NE	1450	26.336	-102.987
coulteri		TEX	K.C.Nixon/1125	1978	Mex.	BC	ND	Ca±on La Borreguera Sa La Libertad 9 mi E of Misi?n San Borja		28.738	-113.604

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coulteri		TEX	J.L.Panero E./4470	1992	Mex.	BC	ND	58 Km al E de Punta Prieta carr a Bahia de Los Angeles		28.967	-113.617
coulteri		NY	M.E.Jones/24064	7 Feb 1928	Mex.	BC		La Paz			
coulteri		GH	A.W.Anthony/348	Mar-Jun 1897	Mex.	BC					
coulteri		GH	I.L.Wiggins/5615	3 May 1931	Mex.	BC					
coulteri		NY	I.L.Wiggins/5615	3 May 1931	Mex.	BC		Between Triunfo and San Bartolo			
coulteri		GH	R.V.Moran/6937	Jan 1959	Mex.	BC					
coulteri		GH	I.L.Wiggins/7856	4 Mar 935	Mex.	BC					
coulteri		TEX	S.W.Sikes/230	1967	Mex.	BCS	LA PAZ	23 mi S of La Paz on rd to Santiago in bar ditch		24.163	-110.307
coulteri		TEX	M.A.Lane/2379	1978	Mex.	BCS	ND	32 Km (20 mi) S of the intersection of Hwy 1 with the rd to El Arco which is between San Ignacio and Guerrero Negro		25.314	-111.909
coulteri		LL	A.M.Carter/2598	1949	Mex.	BCS	LA PAZ	Saltito mouth of Arroyo del Salto E of La Paz		24.234	-110.139
coulteri		LL	A.M.Carter/2627	1949	Mex.	BCS	ND	21 mi SE of La Paz on rd to Los Planes		24.000	-110.000
coulteri		TEX	R.V.Moran/6937	1959	Mex.	BCS	CABOS LOS	Las Cabras aproximadamente 4 km W Santiago cape region		23.450	-109.748
coulteri		GH	A.Carter/2598	30 Mar 1949	Mex.	BCS					
coulteri		GH	A.Carter/3793	14 Mar 1960	Mex.	BCS					

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coulteri		NY	J.N.Rose/13228	22 Mar 191x	Mex.	SIN		Dry hills in the vicinity of San Blas			
coulteri		GH	J.N.Rose/13471	Mar 1910	Mex.	SIN		in the vicinity of Fuerte			
coulteri		NY	J.N.Rose/13471	25 Mar 1910	Mex.	SIN		Sandy soil in the vicinity of Fuerte			
coulteri		NY	J.N.Rose/13539	26 Mar 1910	Mex.	SIN		Dry hills in the vicinity of Fuerte			
coulteri		NY	M.E.Jones/23147	28 Jan 1927	Mex.	SIN		San Blas			
coulteri		GH	H.S.Gentry/5772	29 Feb 1940	Mex.	SIN					
coulteri		NY	H.S.Gentry/5772	29 Feb 1940	Mex.	SIN		Cerro Tecomate, W. of Pericos. Open areas on coastal plain; Thorn forest.	35		
coulteri		NY	H.S.Gentry/7009	14 Mar 1944	Mex.	SIN		Maraton, 12 miles west of Culiacan	35		
coulteri		TEX	A.T.Whittemore/83-044	1983	Mex.	SIN	ND	Hwy 32; 3 mi N of Sibirijoa 30.6 mi NE of Hwy 15 (at Los Mochis)		26.233	-108.717
coulteri		TEX	I.L.Wiggins/8278	1936	Mex.	SON	CABORCA	Heroica Caborca 11 5 mi NW o Wash		30.849	-112.272
coulteri		TEX	R.S.Felger/12192	1965	Mex.	SON	PITIQUITO	Desemboque de Los Seris (El Desemboque) 1.2 km N of San Ignacio Edge of airfield ca 100 m inland from beach		29.514	-112.393
coulteri		GH	H.S.Gentry/1246	31 Jan 1935	Mex.	SON					
coulteri		GH	H.S.Gentry/1329	21 Feb 1935	Mex.	SON					

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coulteri		NY	H.D.Ripley/14303	27 Feb 966	Mex.	SON		6 km N of Empalme, sandy desert			
coulteri		NY	H.D.Ripley/14331	4 Mar 1966	Mex.	SON		Flat sandy ground 10 km SW of Ures.			
coulteri		GH	T.C.Frye/2294	8 Apr 1939	Mex.	SON					
coulteri		NY	T.C.Frye/2294	8 Apr 1939	Mex.	SON		43 km (27 mi.) north of Hermocillo, Sonora, on road to Nogales.			
coulteri		TEX	J.L.Panero E./4417-B	1992	Mex.	SON	ND	Aprox 47 Km al S de Hermosillo carr a Guaymas		28.633	-111.017
coulteri		TEX	A.T.Whittemore/83-060	1983	Mex.	SON	ND	13 mi NE of Hornos 23.4 mi SW of Tezopaco (ca 40 Km NE of Cd Obreg?n)		27.750	-109.750
coulteri		TEX	A.T.Whittemore/83-087	1983	Mex.	SON	ND	Along rd 4 mi N of Nuri		28.167	-109.317
coulteri		TEX	A.T.Whittemore/83-098	1983	Mex.	SON	ND	Km 101 on the Hermosillo-Moctezuma rd; 38.6 mi E of Moctezuma		29.467	-110.250
coulteri		TEX	R.S.Felger/85-602	1985	Mex.	SON	ND	Rancho San Alfonso on rd to Bahia San Pedro		28.099	-111.221
coulteri		NY	F.Shreve/s.n.	6 Mar 1933	Mex.	SON		Near Quiriego, District of Alamos			
coulteri		GH	E.Palmer/172	1800	Mex.						
coulteri		GH	Coulter/463		USA	CA					
cuatrocienegensis		LL	D.L.Venable/769	1975	Mex.	COA	ND	Sa de la Fragua 25 mi S of Custro Ci?negas on Hwy 30 (Coahuila - ND)		28.578	-102.435

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cuatrocienegensis		TEX-type	J.L.Neff/	1992	Mex.	COA	CUATROCI?NEGAS	27 Km SW on MX 30 then 14 Km SE Sa San Marcos y Pinos		26.817	-102.050
demissa	covillei	GH	S.B.Parish/10065	18 May 1915	USA	CA					
demissa	covillei	GH	S.B.Parish/10198	14 Ma 1915	UsA	CA					
demissa	covillei	GH	A.N.Steward/7405	20 Mar 1958	USA	CA					
demissa	covillei	GH	A.Eastwood/7729	27 Mar 1940	USA	CA	Inyo				
demissa	demissa	GH	A.Nelson/1243	20 Mar 1935	USA	AZ					
demissa	demissa	GH	K.M.Wiegand/1811	8 May 1935	USA	AZ	Mohave				
demissa	demissa	GH	S.D.McKelvey/2185	12 May 1931	USA	AZ	Mohave				
demissa	demissa	GH	S.D.McKelvey/2201	13 May 1931	USA	AZ	Mohave				
demissa	demissa	GH	J.W.Gillespie/5331	12 Mar 1932	USA	AZ	Maricopa				
demissa	demissa	GH	P.H.Raven/11836	15 Mar 1958	USA	CA	Riverside				
demissa	demissa	TEX	D.Charlton/1291	6 Mar 1988	USA	CA	San Bernardino				
demissa	demissa	TEX	B.Prigge/1375	23 Apr 194	USA	CA	San Bernardino				
demissa	demissa	GH	K.M.Wiegand/1810	4 May 1935	USA	CA	Inyo				
demissa	demissa	TEX	L.Gross/1930	12 Apr 2005	USA	CA	San Bernardino				
demissa	demissa	GH	A.M.Alexander/1964	19 Mar 1941	USA	CA	Imperial	east side of Algodones sand dunes, Colorado Desert			
demissa	demissa	GH	A.M.Alexander/1983	21 Mar 1941	UsA	CA	Imperial				
demissa	demissa	GH	M.F.Spencer/207	29 Mar 1917	UsA	CA					
demissa	demissa	GH	A.Eastwood/2635	12 Apr 1913	USA	CA	San Diego				

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demissa	demissa	TEX	G.Helmkamp/2847	16 Mar 1998	USA	CA	San Bernardino				
demissa	demissa	GH	H.L.Mason/3077	2 Apr 1926	USA	CA	San Bernardino				
demissa	demissa	GH	V.Duran/3239	1 Jun 1932	USA	CA	Mono				
demissa	demissa	GH	A.Nelson/3322	29 Mar 1939	USA	CA					
demissa	demissa	TEX	R.L.Hartman/3527	19 Apr 1973	USA	CA	San Bernardino				
demissa	demissa	GH	L.S.Rose/40275	10 May 1940	USA	CA	Kern				
demissa	demissa	GH	S.B.Parish/4128	4-13 Apr 1896	USA	CA					
demissa	demissa	GH	R.C.Foster/49	7 Mar 1937	USA	CA					
demissa	demissa	TEX	R.R.Halse/5970	27 Mar 2001	USA	CA	San Bernardino				
demissa	demissa	GH	C.B.Wolf/6470	27 Apr 1935	USA	CA	San Bernardino				
demissa	demissa	GH	F.V.Coville/758	15 MAY 189	USA	CA					
demissa	demissa	GH	A.A.Heller/7701	14 Apr 1905	USA	CA	Kern				
demissa	demissa	TEX	Vasek/7c	28 Apr 1978	USA	CA	San Bernardino				
demissa	demissa	GH	A.A.Heller/8280	18 May 1906	USA	CA	Inyo				
demissa	demissa	GH	I.L.Wiggins/9655	26 Mar 1941	USA	CA	Imperial				
demissa	demissa	GH	S.B.Parish/9765	26 Apr 1915	USA	CA					
demissa	demissa	GH	A.Eastwood/s.n.	30 April 1913	USA	CA	San Bernardino				
demissa	demissa	GH	J.Arnold/s.ns	26 Mar 1937	USA	CA					
demissa	demissa	GH	P.B.Kennedy/1843	5 May 1909	USA	NV	Clark				
demissa	demissa	GH	L.N.Goodding/2204	8 Apr 1905	USA	NV					
demissa	demissa	GH	L.N.Goodding/2331	8 May 1905	USA	NV					

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demissa	demissa	GH	A.A.Heller/9645	18 May 1909	USA	NV	Nye				
demissa	demissa	GH	A.Cronquist/9964	10 May 1964	USA	NV	Clark				
demissa	demissa	GH	C.c.Parry/185	1874	USA	UT					
demissa	demissa	GH	C.C.Parry/185 (dup)	May 1874	USA	UT					
demissa	demissa	GH	C.L.Hitchcock/3067	12 May 1937	USA	UT					
demissa	demissa	GH	C.R.Orecutt/s.n.	May 1882							
demissa	deserti	TEX	J.Neff/24	6 May 1973	USA	AZ	Maricopa				
demissa	deserti	TEX	C.B.Wolf/6470	27 Apr 1935	USA	CA	San Bernardino				
demissa	deserti	TEX	J.Henrickson/8625	18 Mar 1973	USA	CA	San Diego				
demissa	linearis	GH	P.H.Raven/12604	Apr 1958	Mex.	BC					
demissa	linearis	GH	F.Shreve/6976	27 Feb 1935	Mex.	BC					
demissa	linearis	GH	E.Palmer/808	1889	USA	CA					
demissa	linearis	GH	T.S.Brandegee/s.n.	2 Feb 1889	USA	CA		San Gregorio			
demissa		TEX	K.C.Nixon/872	1977	Mex.	BC	ENSENADA	Mina El Desenga±o ruins 2 mi N 5 mi N of M?x Hwy 1 (to Bah?a de Los Angeles)		29.135	-114.073
demissa		TEX	P.Fritsch/1336	1992	Mex.	BC	ENSENADA	Bah?a de Los Angeles SW shore ca intersection of a rd leading to the beach		28.958	-113.560
demissa		TEX	J.Spencer/11	1997	Mex.	CHI	NUEVO CASAS GRANDES	17 Km S from Nvo Casas Grandes in dry wash bottom		30.268	-107.956
demissa		TEX	L.R.Landrum/5368	16 Feb 1987	USA	AZ	Maricopa				

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demissa		TEX	W.C.Bryan/61	8 Apr 196	USA	AZ	Pima				
demissa		TEX	C.L.Hitchcock/25704	18 Mar 1970	USA	CA	Imperial				
demissa		TEX	A.L.Moldenke/30734	27 Apr 1976	USA	CA	San Bernardino				
demissa		TEX	B.Ertter/5996	20 Apr 1986	USA	CA	Kern				
demissa		TEX	Mrs. H.C.Cantelow/Hy.466	27 Apr 1942	USA	CA	San Bernardino				
demissa		TEX	A.Cronquist/9964	10 May 1964	USA	NV	Clark				
demissa		TEX	R.J.Davis/s.n.	2 May 1954	USA	NV					
demissa		GH	S.Watson/888	Jun 1869	USA	UT		illeg	1300		
densa	densa	GH	J.W.Thompson/13166	8 Jul 1936	USA	CA	Siskiyou				
densa	densa	GH	L.Constance/3098	3 Jul 1946	USA	CA	Lassen				
densa	densa	GH	L.S.Rose/42143	29 Jul 1942	USA	CA	Mono				
densa	densa	GH	A.M.Alexander/4304	25 Jun 1945	USA	CA	Mono				
densa	densa	GH	V.Duran/566	23 Jul 1930	USA	CA					
densa	densa	GH	A.A.Heller/8325	23 May 1906	USA	CA	Inyo				
densa	densa	GH	W.G.Huckley/382	1886	USA	NV					
densa	densa	GH	A.Gray/s.n.	1872	USA	NV					
densa	densa	GH	J.W.Thompson/12018	12 Jul 1935	USA	OR	Harney				
densa	densa	GH	J.W.Thompson/12193	19 Jul 1935	USA	OR	Klamath				
densa	densa	GH	anon/2	19 Jun 1919	USA	OR					
densa	densa	GH	J.C.Nelson/5022	18 Jun 1926	USA	OR	Klamath				
densa	densa	GH	F.Shreve/9522	29 Jun 1940	USA	OR					
densa	densa	GH	M.E.Peck/9593	20 Jul	USA	OR	Klamath				

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				1920							
densa	densa	GH	J.W.Congdon/s.n.	12 Aug 1898							
densa		TEX	L.S.Rose/42143	29 Jul 1942	USA	CA	Mono				
densa		TEX	A.M.Alexander/4304	25 Jun 1945	USA	CA	Mono				
densa		TEX	L.Constance/3716	19 Jul 1961	USA	NV	Humboldt				
depressa		GH	S.B.Parish/1334	May 1882	USA	CA	San Bernardino				
depressa		GH	?/313b	1884	USA	CA					
depressa		GH	L.Constance/3401	7 Apr 1952	USA	CA	San Bernardino				
depressa		GH	L.Constance/3403	9 Apr 1952	USA	CA	San Bernardino				
depressa		TEX	L.Constance/3403	9 Apr 1952	USA	CA	San Bernardino				
depressa		TEX	J.D.Morefield/3504 (dupl. n)	24 Apr 1986	USA	CA	Mono				
depressa		RSA	J.M.Porter/11766	25 Apr 1998	USA	CA	San Bernardino	Salt Wells Canyon: Narrows of Salt Wells Canyon, draining Salt Wells Valley on the south side of Hwy 178.		35.657	116.548
depressa		RSA	J.Henrickson/16575	3 Apr 1978	USA	CA	San Bernardino	ca. 8 miles N of Barstow along road between Rainbow Basin and Owl Canyon Campground, S. of Mud Hills	1000		
depressa		RSA	H.D.Ripley/3295	2 May 1941	USA	CA	San Bernardino	Desert valley 7 miles N of Barstow	900		
depressa		RSA	M.DeDecker/3392	24 Apr 1974	USA	CA	Inyo	Owens Valley nw of Fort Independence Section 35, T12S, R34E, MDM.	1320		

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depressa		RSA	J.D.Morefield/3455 dupl.a	19 Apr 1986	USA	CA	Mono	About 1.5 mi. below mouth of Pellisier Cr. Near road, 1.5 mi. S77degW of Mt. View & Proctor Mine, T3S R32E S1. Owens Valley drainage	1690		
depressa		RSA	P.A.Munz/4087	25 May 1920	USA	CA		Newberry			
depressa		RSA	C.Davidson/4309	8 Jun 1976	USA	CA	Inyo	On Hwy 190 (to Death Valley), 6.4 mi E of junction with Hwy 136 (from Lone Pine).	1500		
depressa		RSA	R.Gustafson/474	11 May 1977	USA	CA	Kern	About 1/2 mile west from Hwy 13 on the road leading to the Red Rock Canyon campground, 21 miles north of Mohave along sandy road embankment			
depressa		RSA	D.Charlton/5074	3 May 1991	USA	CA	Kern	South Siphon Rd out of Cinco, 17 miles north of Mojove. Aqueduct Rd. just south of Jawbone Canyon, Hwy 14. Foothills of the Sierra Nevadas	900		
depressa		RSA	J.Roos/5635	10 May 1952	USA	CA	San Bernardino	4 miles northwest of Adelanto, near Red Raven mine.	900		
dichotoma	amplifolia	GH	Jorgensen/1728		Arg.	CAT	Andalgala	La Junta			
dichotoma	amplifolia		Mandon/in 1858		Bol.	GLO	Calavaya				

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dichotoma	amplifolia	GH	Bang/958		Bolivia			Cochabamba			
dichotoma	angustifolia	GH	A.Fendler/644	1847							
dichotoma	chasmogama	GH	L.O.Williams/22014	29 Nov 1962	Guat.	HUE		Sierra de los Chuchumatanes just below Calaveras	3000		
dichotoma	chasmogama	GH	Ghiesbreght/614	1864-70	Mex.	CHIA					
dichotoma	chasmogama	GH	C.G.Pringle/11638	16 Sep 1903	Mex.	HID		Hills, El Salto Station	2130		
dichotoma	chasmogama	GH	H.E.Moore, Jr./4929	16 Sep 1948	Mex.	HID		Near km. 275-76 on highway northeast of Jacala	1430		
dichotoma	chasmogama	GH	E.Seler/1554	4 Dec 1895	Mex.	OAX		Teposcolula			
dichotoma	chasmogama	GH	E.Palmer/170	28 Sep to 3 Oct 1902	Mex.	SLP		Alarez			
dichotoma	chasmogama	GH	C.G.Pringle/3312	30 Sep 1890	Mex.	SLP		Hills, Las Canoas			
dichotoma	chasmogama	GH	M.Bourgeau/3163	26 Sep 1865 or 1866	Mex.			Borrego, Region de Grizaba			
dichotoma	dichotoma	GH	P.Joergensen/1728		Arg.	CAT					
dichotoma	dichotoma	GH	P.Jorgensen/1728	1917	Arg.	CAT		illeg. La Junta	1960		
dichotoma	dichotoma	GH	P.Cantino/755	22 Mar 1973	Arg.	CAT	Andalgala	8 km W of Andalgala. In the shade of large Prosopis chilensis and Celtis spinosa trees along Rio Choya.	990		
dichotoma	dichotoma	GH	O.Buchtien/9339	29 Mar 1933	Bolivia			La Paz: bei Obrajes auf KulSurland	3450		
dichotoma	dichotoma	GH	A.M.Bang/958	1891	Bolivia			Cochabamba			
dichotoma	dichotoma	GH	G.Mandon/illeg	Feb 1858	Bolivia			illeg.	2700		
dichotoma	dichotoma	GH	R.Spruce/5802	1857-9	Ecuador			n Andibus Ecuadorensibus			

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dichotoma	dichotoma	GH	R.M.Stewart/2543	25 Sep 1942	Mex.	CHI		Canon de la Madera (5 km up the canyon), southeastern flank of Sierra Rica, north of Rancho de la Madera.			
dichotoma	dichotoma	GH	C.G.Pringle/775	15 Oct 1886	Mex.	CHI		Mts. Near Chihuahua			
dichotoma	dichotoma	GH	I.M.Johnston/601	24 Aug 1940	Mex.	COA		Sierra del Pino: western ridge, west of camp at La Noria			
dichotoma	dichotoma	GH	C.R.Orcutt/4337	3 Oct 1910	Mex.	DF		Xochimilco			
dichotoma	dichotoma	GH	C.G.Pringle/9362	7 Sep 1901	Mex.	DF		Eslava, Valley of Mexico	2500		
dichotoma	dichotoma	GH	E.Palmer/501	21-27 Aug 1906	Mex.	DUR		Tejamen, Durango			
dichotoma	dichotoma	GH	E.Palmer/698	Sep 1896	Mex.	DUR		Vicinity of city of Durango			
dichotoma	dichotoma	GH	H.E., Jr.Moore/1668	27 Oct 1946	Mex.	HID	Jacala	Puerto de la Zorra, near Km 284 on highway north of Jacala	1500		
dichotoma	dichotoma	GH	C.R.Orcutt/4134	21 Sep 1910	Mex.	HID		Telles			
dichotoma	dichotoma	GH	C.A.Purpus/5661	Oct 1911	Mex.	PUE		Boca del Monte			
dichotoma	dichotoma	GH	C.C.Parry/610	1878	Mex.	SLP					
dichotoma	dichotoma	GH	C.A.Purpus/1704	Dec 1905	Mex.			Salto de Agua			
dichotoma	dichotoma	GH	J.F.Macbride/3192	5 Apr 1923	Peru	AMB			2100		
dichotoma	dichotoma	GH	C.Vargas C./7939	27 Mar 1949	Peru	ARE	Arequipa	cerros de Jesus	2360		
dichotoma	dichotoma	GH	C.Vargas C./8575	11-12 Nov 1949	Peru	MOQ	Moquegua	Ilo lomas de Mostacilla	50		
dichotoma	dichotoma	GH	A.Weberbauer/7409	17-18	Peru	MOQ	Torata	Torata, Prov.	2200		

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dichotoma	dichotoma	GH	Pennell/13054	Mar 1925	Peru		Arequipa	Moquegua Arequipa			
dichotoma	dichotoma	GH	Pennell/13108		Peru		Arequipa	Tingo			
dichotoma	dichotoma	GH	Pennell/13679		Peru		Cusco	Ollamtaitambo			
dichotoma	dichotoma	GH	J.Soukup/2959	Mar 1946	Peru			Jhranceyo (illeg)	3317		
dichotoma	dichotoma	GH	Macbride/3192		Peru			Ambo			
dichotoma	dichotoma	GH	A.Weberbauer/5291	Apr 1910	Peru			San Bartolome (Lima-Oroya-Railroad)	1500		
dichotoma	dichotoma	GH	Weberbauer/5291		Peru			San Bartoome			
dichotoma	dichotoma	GH	F.E.Hinkley/74	Mar 1920	Peru			Southern slopes of Chachani Mountain North of Arequipa	3660		
dichotoma	dichotoma	GH	Hinkley/74		Peru			south slopes of Chachani Mt., north of Arequipa			
dichotoma	dichotoma	GH	J.C.Blumer/3370	17 & 20 Sep 1909	USA	AZ		Mouring Camp	2500		
dichotoma	dichotoma	GH	T.S.Brandegee/1046	Sep 1874	USA	CO	Fremont	Wild Cut Park			
dichotoma	dichotoma	GH	E.L.Greene/361	12 Sep 1880	USA	NM		Near Silver City			
dichotoma	dichotoma	GH	A.A.Heller/3846	13 Jul 1897	USA	NM		Santa Fe Canon, 9 miles east of Santa Fe			
dichotoma	dichotoma	LL	R.Spellenberg/3926	8 Sep 1974	USA	NM	Sierra				
dichotoma	dichotoma	GH	P.C.Standley/5056	18 Aug 1908	USA	NM	San Miguel	near Pecos	2100		
dichotoma	dichotoma	GH	A.Fendler/644	1847	USA	NM					
dichotoma	dichotoma	GH	D.S.Correll/33744	20 Sep 1966	USA	TX	Jeff Davis	in gravelly bare soil near summit of Mt. Livermore			
dichotoma	dichotoma	GH	V.L.Cory/7198	9 Sep 1933	USA	TX	Brewster	Camp Mt., Chisos Mts.			
dichotoma	dichotoma	GH	C.Wright/1584	1851-52				N. Mex.			

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dichotoma	latisepala	GH	E.Seler/1463	7 Dec 1895	Mex.	OAX		Teaxiaro			
dichotoma		BOLV, MO?	C.Antezana/1281	2 May 1999	Boliva			Cochabamba, Campero	2290		
dichotoma		GH	Philippi/		Chile			Paposo			
dichotoma		TEX	C.Sant?z R./262	1987	Mex.	CHIA	CHAMULA	Chicumtantic.		16.864	-92.605
dichotoma		TEX	F.Gomez S./354	1988	Mex.	CHIA	OXCHUC	Tzajalococh (3 km al norte de escuela de Tz'unum)		16.862	-92.329
dichotoma		TEX	J.Brett/497	1991	Mex.	CHIA	CHIL?N	Honteel		17.209	-91.833
dichotoma		TEX	E.Sant?z C./764	1988	Mex.	CHIA	CHIL?N	Honteel 4 Km.		17.209	-91.833
dichotoma		LL	D.E.Breedlove/14075	1965	Mex.	CHIA	SAN CRISTOBAL DE LAS CASAS	Cerca de Rancho Nuevo alrededor de 9 mi SE de San Crist?bal de las Casas		16.669	-92.563
dichotoma		LL	D.E.Breedlove/28717	1972	Mex.	CHIA	ZINACANT?N	Paste		16.707	-92.741
dichotoma		LL	C.G.Pringle/775	1886	Mex.	CHI	Chihuahua	Mts near Chihuahua		28.635	-106.089
dichotoma		TEX	Quintana/3118	1994	Mex.	CHI	GOMEZ FARAS	Al E de la Laguna Babacora		29.351	-107.801
dichotoma		LL	I.M.Johnston/601	1940	Mex.	COA	ND	Sa del Pino: Western ridge W of camp at La Noria		28.237	-103.066
dichotoma		LL	T.L.Wendt/1736	1976	Mex.	COA	ND	1.2 mi E of Tanque El Toro and 4.2 mi E of Rancho Charretera along rd to Cuatro Ci?nagas in Nern bajada area of range (Coahuila - ND)		27.153	-102.363

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dichotoma		LL	T.L.Wendt/1749	1976	Mex.	COA	ND	1.2 mi E of Tanque El Toro and 4.2 mi E of Rancho Charretera along rd to Cuatro Ci?nagas in Nern bajada area of range (Coahuila - ND)		27.153	-102.363
dichotoma		TEX	McDonald/2164.5	1986	Mex.	COA	SALTILLO	Saltillo SE ridge top and SE slope of Sierra Coahuilon		25.362	-100.974
dichotoma		TEX	J.Grimes/2289	1982	Mex.	COA	ARTEAGA	La Viga (Cerro)		25.331	-100.431
dichotoma		TEX	G.B.Hinton/20729	1990	Mex.	COA	ARTEAGA	Sa de La Nieve (Coahuila - ARTEAGA)		25.406	-100.725
dichotoma		LL	F.Chiang C/9535b	1972	Mex.	COA	TORRE?N	OTTO (Estaci?n) 8 Km NE of Sierra de Jimulco and up to 3 Km N of Mina San Jos? wich is		25.134	-103.231
dichotoma		TEX	C.R.Orcutt/4337	1910	Mex.	DF	XOCHIMILCO	Xochimilco Valley of M?x		19.275	-99.139
dichotoma		TEX	J.L.Neff/92-3-16-4	1992	Mex.	DUR	ND	2 Km NE of La Flor		26.575	-103.941
dichotoma		TEX	I.Diaz V./169	1988	Mex.	HID	AJACUBA	La barranca localidad al N del poblado Emiliano Zapata vertiente S de la Sa de Chicavasco ej. E. Zapata		20.150	-99.025
dichotoma		LL	D.S.Lewis/161	1975	Mex.	NL	GALEANA	Cerro El Potos?.		24.868	-100.232
dichotoma		TEX	McDonald/2074	1986	Mex.	NL	GENERAL ZARAGOZA	Pe±a Nevada Sierra (Nuevo Leon - GENERAL ZARAGOZA)		23.802	-99.845
dichotoma		TEX	M.Lavin/4830	1984	Mex.	NL	GALEANA	Galeana.		24.824	-100.077

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dichotoma		TEX	E.L.Bridges/13107	1990	Mex.	NL	GALEANA	on W side of M?x 57 in sharp turn 4.3 Km S of rd to Puerto M?x ca 4.5 air Km E of El Prado 10 Km S of Coahuila state line ca 20 Km NW of San Rafael; Cerro Atravesado Huachichil		25.144	-100.691
dichotoma		TEX	G.B.Hinton/19767	1989	Mex.	NL	GALEANA	Samaniego y La Becerra.		25.081	-100.543
dichotoma		TEX	G.B.Hinton/21486	1991	Mex.	NL	ITURBIDE	La Pur?sima 2.79 Km al SE rumbo a Buena Vista.		24.517	-99.812
dichotoma		TEX	G.B.Hinton/25635	1995	Mex.	NL	GALEANA	Entre Ci?nega del Toro y Santa Rosa		25.088	-100.267
dichotoma		TEX	G.B.Hinton/27643	2000	Mex.	NL	ALLENDE	Ra?ces 31.65 Km al SE carr a La Chona.		25.121	-99.801
dichotoma		TEX	R.Torres C./2851	1983	Mex.	OAX	VILLA D?AZ ORDAZ	Villa D?az Ordaz		17.134	-96.384
dichotoma		TEX	R.W.Cruden/2114	1973	Mex.	PUE	TEHUAC?N	Rte 125 ca 45 km SW of Tehuacßn		18.227	-97.590
dichotoma		TEX	B.L.Turner/15272	1983	Mex.	PUE	ND	18 air Km NW of Perote (Veracruz) on N upper slope of Cerro Arenas along rd		19.650	-97.450
dichotoma		TEX	B.L.Turner/15276	1983	Mex.	PUE	ND	18 air Km NW of Perote (Veracruz) on N upper slope of Cerro Arenas along rd		19.650	-97.450

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dichotoma		TEX	B.L.Turner/15280	1983	Mex.	PUE	ND	18 air Km NW of Perote (Veracruz) on N upper slope of Cerro Arenas along rd		19.650	-97.450
dichotoma		TEX	C.P.Cowan/5470	1985	Mex.	QUE	CADEREYTA DE MONTES	0.7 mi (1.1 Km) S of Higuerillas on dirt rd (terracer?a) S of Hwy (Higuerillas-San Pablo Tolimßn)		20.916	-99.757
dichotoma		LL	B.L.Turner/76-22	1976	Mex.	QUE	PINAL DE AMOLES	E Pinal de Amoles 1.5 mi E rd between Vizarr?n and Jalpan		21.146	-99.619
dichotoma		TEX	F.A.Barkley/819	1947	Mex.	SLP	SAN LUIS POTOS?	4 mi NE of SLP		22.197	-100.938
dichotoma		LL	M.C.Johnston/12280	1973	Mex.	SLP	ND	38 Km NW of SLP and 19 Km NW of M?xquitic on Hwy to Zacatecas		22.350	-101.250
dichotoma		LL	F.Chiang C/8214f	1972	Mex.	SLP	ND	3 Km N of Moctezuma on rd to Venados		22.767	-101.083
dichotoma		LL	F.Ventura A./9166	1973	Mex.	VER	PEROTE	San Antonio Lim?n (Totalco)		19.502	-97.348
dichotoma		TEX	B.L.Turner/15436	1983	Mex.	VER	PEROTE	2 mi SW of Totalco on W slope of rocky limestone ridge		19.467	-97.367
dichotoma		TEX	J.S.Henrickson/6233	1971	Mex.	ZAC	ND	0.5 mi S of the Zacatecas-Coahuila border along M?x Hwy 54		24.717	-101.217
dichotoma		TEX	J.S.Henrickson/6352	1971	Mex.	ZAC	CONCEPCI?N DEL ORO	35 (air) mi NNW of Concepci?n del Oro 10 mi W of Cedras		24.633	-101.933

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dichotoma		TEX	J.S.Henrickson/13463	1973	Mex.	ZAC	MAZAPIL	Estaci?n Camacho 15 (air) mi NE; ladera NW del cerro Pico de Teyra		24.558	-102.173
dichotoma		TEX	J.S.Henrickson/13494-B	1973	Mex.	ZAC	MAZAPIL	Estaci?n Camacho 15 mi NE; Sierra El Solitario de Teyra; (NW of Pico de Teyra)		24.594	-102.218
dichotoma		TEX	J.S.Henrickson/13520-C	1973	Mex.	ZAC	ND	Ca 25 (air) mi NNE of Estaci?n Camacho 2.5 mi SE of Apisolaya on rd to San Juan de Los Cedros		24.783	-102.217
dichotoma		MO	A.Sagastegui/8731	23 Sep 1976	Peru	LIB	Trujillo	Cerro Cabezon	400		
dichotoma		MO	R.Ferreyra/12539	Oct 1957	Peru	TAC	Tacna		500		
dichotoma		TEX	S.Leiva G./1441	9 Sep 1986	Peru	TRU	La Libertad	Lomas de Viru			
dichotoma		TEX	J.Mostacero L./1441	15 Sep 1986	Peru	TRU	La Libertad				
dichotoma		LL	R.Hutchins/2467	18 Aug 1969	USA	NM	Lincoln				
dichotoma		LL	D.S.Correll/33744	9/20/66		TX	JEFF DAVIS	In gravelly bare soil near summit of Mt. Livermore.			
dichotoma		TEX	R.D.Worthington/3471	9/10/78		TX	EL PASO	"Franling Mountains, 0.3 air mi NNW-NW top North Franklin Mountain, 6700 ft elev."		31.906	105.503
dichotoma		TEX	R.D.Worthington/3501	9/16/78		TX	El Paso	"Franklin Mountains, top of South Franklin Mountain, 6700 ft. elev."			

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dichotoma		TEX	A.M.Powell/4889	9/1/84		TX	Jeff Davis	"Davis Mountains, Mt. Livermore, NE slopes in and near Madera Canyon, and on the peak."			
dichotoma		TEX	L.C.Hinckley/s.n.	10/12/35		TX	Jeff Davis	"Goat Canyon, Mt. Livermore."			
dichotoma		TEX	M.S.Young/s.n.	9/12/16		TX	Culberson	"Guadalupe Mountains, Texas."			
flavescens		LL, TEX	F.Chiang/10081	4 Nov 1972	Mex.	COA	ND	Sa de Parras N slope and top approached from Ejido Cerro Colorado ca 10 Km W of Parras de La Fuente	1500	25.433	-102.267
flavescens		GH	C.A.Purpus/117	1903	Mex.	COA					
flavescens		NY	H.D.Ripley/13512	11 Nov 1963	Mex.	COA		n. slope of Sierra de Parras, back of Parras			
flavescens		US	C.A.Purpus/1875	Feb 1906	Mex.	COA		Parras			
flavescens		GH	C.A.Purpus/1875	Feb 1906	Mex.	COA	Parras	gravelly soil			
flavescens		NY	D.S.Correll/21413	3 May 1959	Mex.	COA		West base and slopes of Sierra Solis, about 5 miles north of Matamoros.			
flavescens		TEX	H.S.Gentry/23103	7 Oct 1972	Mex.	COA	PARRAS	Parras de La Fuente (Parras) 2.5 mi SW of	2000	25.414	-102.208
flavescens		GH	C.H.Muller/3031	29 Aug 1939	Mex.	COA					
flavescens		GH	Kenoyer/3218	25 Aug 1948	Mex.	COA					
flavescens		NY	Heil-Porter-Fleming/5017	17 May 1989	Mex.	COA	Coahuila, S.T.R (?)	Ca 10 mi E of Saltillo towards Monterey & ca 1 mi up canyon with chicken ranches	1600		

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flavescens		GH	Pena-Poza/843	Nov 1802	Mex.	COA					
flavescens		GH	F.Shreve/9864	5 Sep 1940	Mex.	COA					
flavescens		GH	F.Shreve/9896	6 Sep 1940	Mex.	COA					
flavescens		NY	Engard/H1809	10 Jul 1982	Mex.	COA		55-60 mi NE of San Pedros de las Colonias, SW of Cuatro Cienegas, off Rt 30.			
flavescens		LL	M.C.Johnston/10483	1973	Mex.	ZAC	ND	5 Km NE of Estaci?n La Laja; 8 Km ENE of Concepci?n del Oro		24.633	-101.350
flavescens		LL	M.C.Johnston/11526	1973	Mex.	ZAC	ND	Near and at Sa de Yeso almost due W of La Presa de Los Angeles		25.067	-102.117
flavescens		LL	M.C.Johnston/11543 a	1973	Mex.	ZAC	ND	SE of Cedros		24.672	-101.756
flavescens		GH	F.E.Lloyd/143	Oct 1907	Mex.	ZAC					
flavescens		LL, TEX	F.Chiang/7926	17 Jun 1972	Mex.	ZAC		1 km SE of San Juan de los Cedros, on road to Mazapil	1650	24.667	100.233
flavescens		GH	E.Palmer/d62 (?)	1880	Mex.						
havardii	alba	GH	V.L.Cory/18602	13 Apr 1936	USA	TX	Brewster	2 1/4 m. NE of Agua Fria Springs			
havardii		TEX	A.M.Powell/1990	1971	Mex.	CHI	OJINAGA	Manuel Ojinaga		29.482	-104.414
havardii		TEX	A.M.Powell/2037	1971	Mex.	CHI	ND	11 mi E of Hwy 16 on rd to new lake on R?o Conchos		29.167	-105.083
havardii		TEX	R.M.Stewart/2432	1942	Mex.	CHI	MADERA	Madera		29.184	-108.136
havardii		TEX	J.S.Henrickson/7681	1972	Mex.	CHI	ND	6.5 (rd) mi ENE of Coyame along Hwy 16		29.467	-104.950

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havardii		LL	F.Chiang C/9676	1972	Mex.	CHI	ND	Just S of Rancho El Bosque where R?o San Carlos cuts through the Mesa de Anguila		29.158	-103.717
havardii		LL	F.Chiang C/9721	1972	Mex.	CHI	ND	Ca 9 Km W of Ojinaga on the Hwy to Chihuahua City		29.578	-104.467
havardii		LL	F.Chiang C/9774	1972	Mex.	CHI	ND	Base (E) of N end of Sa del Cuchillo Parado where crossed by Ojinaga-Cd Chihuahua Hwy 60 Km W of Ojinaga		29.600	-104.900
havardii		LL	M.C.Johnston/11369	1973	Mex.	CHI	ND	R?o Conchos ca 20 KM downstream (N) from Julimes across from Rancho Monte Seco		28.600	-105.400
havardii		LL	M.C.Johnston/11373	1973	Mex.	CHI	ND	Mouth of Arroyo Carrizo about 20 Km N of Julimes downstream near R?o Conchos at Rancho Laborcita		28.600	-105.400
havardii		LL	M.C.Johnston/12301	1973	Mex.	CHI	ND	Sa del Roque N of Julimes N and NW of Rancho El Sauz		28.650	-105.300
havardii		TEX	M.C.Johnston/12893	1985	Mex.	CHI	ND	Near R?o Grande NE of Sa Mulato Swiss Cheese Canyon side canyon in lower part of Colorado Canyon		29.283	-103.967

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havardii		LL	M.C.Johnston/10568 -A	1973	Mex.	CHI	ND	8 Km from R. Boquillas P?rez toward Ej Cuchillo Parado (from San Luis on La Perla rd toward Coyame on Ojinaga Hwy)		29.317	-104.833
havardii		GH	R.M.Stewart/2312	21 Sep 1942	Mex.	CHI					
havardii		GH	R.M.Stewart/2325	21 Sep 1942	Mex.	CHI					
havardii		GH	R.M.Stewart/2432	24 Sep 1942	Mex.	CHI					
havardii		GH	R.M.Stewart/2432 (dupl)	24 Sep 1942	Mex.	CHI					
havardii		GH	I.M.Johnston/8043	9-10 Aug 1941	Mex.	CHI					
havardii		GH	I.M.Johnston/9416	10 Oct 1941	Mex.	CHI					
havardii		TEX	I.M.Johnston/159	1940	Mex.	COA	SIERRA MOJADA	Between Carrizo and Carricito rd from Picachos Colorados S to Castill?n		28.205	-103.556
havardii		TEX	I.M.Johnston/228	1940	Mex.	COA	ND	Sa de las Cruces; Eern foothills in the vicinity on Santa Elena Mines		27.967	-103.700
havardii		TEX	R.M.Stewart/598	1941	Mex.	COA	SIERRA MOJADA	Sierra de Cruces E-ern foothills of the E base of Picacho de San Jos? vicinity of Santa Elena Mines		27.977	-103.697
havardii		TEX	R.M.Stewart/1790	1941	Mex.	COA	ND	2 Km S of El Pino		26.340	-101.370

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havardii		LL	F.Chiang C/9236	1972	Mex.	COA	ND	4.5 Km S of Boquillas on the Muzquiz Hwy between El Milagro turnoff and Santa Rosa turnoff		28.875	-102.758
havardii		LL	F.Chiang C/9358	1972	Mex.	COA	ND	8 Km WSW of Santa Rosa about 17 Km E of the Sa de San Vicente		28.883	-102.867
havardii		LL	M.C.Johnston/10599	1973	Mex.	COA	ND	San Rosendo Canyon (flows into R?o Grande opposite Brewster County Texas)		28.867	-102.567
havardii		GH	I.M.Johnston/1271	15 Sep 1940	Mex.	COA					
havardii		GH	I.M.Johnston/139	11 Aug 1940	Mex.	COA					
havardii		GH	I.M.Johnston/159	11-12 Aug 1940	Mex.	COA					
havardii		GH	R.M.Stewart/1790	21 Sep 1941	Mex.	COA					
havardii		GH	I.M.Johnston/228	13 Aug 1940	Mex.	COA					
havardii		GH	R.M.Stewart/315	27 Oct 1940	Mex.	COA					
havardii		GH	R.M.Stewart/598	23 Jun 1941	Mex.	COA					
havardii		GH	I.M.Johnston/8191	13 Aug 1941	Mex.	COA					
havardii		LL	M.C.Johnston/10235 -A	1973	Mex.	MICH	ERONGAR?C UARO	Cercanias a San Miguel Nocutzepo		19.528	-101.698
havardii		LL	M.C.Johnston/10255 -B	1973	Mex.	NL	ND	Minas Manto Blanco y Sabana Blanca just N of the Ca±?n de Potrerillos		26.067	-100.750
havardii		US	V.Havard/95 1/2	Aug 1883	USA	TX		Alkali bank, Tornillo Cr.			

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havardii		GH	B.L.Turner/1082	s.d.	USA	TX	Brewster				
havardii		GH	L.C.Hinckley/1631	10 Jun 1941	USA	TX	Presidio				
havardii		GH	D.S.Correll/19406	7 Jul 195	USA	TX	Val Verde				
havardii		GH	H.Cutler/21159	4 Mar 1937	USA	TX	Brewster				
havardii		GH	V.L.Cory/2229	6 May 1928	USA	TX	Brewster				
havardii		GH	A.Traverse/2241	13 May 1961	USA	TX	Brewster				
havardii		GH	A.Nelson/5044	2 Apr 1942	USA	TX	Brewster				
havardii		GH	R.R.Innes/531	19 Mar 1941	USA	TX	Brewster				
havardii		GH	V.Havard/95 1/2	Aug 1883	USA	TX		Alkali bank of Tornillo Creek			
havardii		GH	V.L.Cory/s.n.	13 Apr 1936	USA	TX	Brewster				
havardii		GH	V.L.Cory/s.n.	27 Apr 1928	USA	TX	Brewster				
havardii		LL	D.H.Riskind/1008			TX	Brewster	Black Gap Wildlife Refuge upstream from Big Canyon (a tributary of the Rio Grande) on the Rio Grande.			
havardii		LL	M.C.Johnston/10626	4/11/73		TX	Terrell	San Francisco Canyon mouth and lowest part of Isinglass Canyon very near the Brewster County line. Altitude 475m.		29.892	101.667
havardii		TEX	J.Henrickson/11303	7/25/73		TX	BREWSTER	1 mile E of Terlingua along Hwy 170 on silty-limestone roadside.			

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havardii		LL	C.M.Rowell/1180	4/8/67		TX	Brewster	Black Gap Wildlife Management Area 57 miles south of Marathon.			
havardii		TEX	R. R.Innes/1183	6/16/41		TX	Brewster	"Terlingua creek at bridge, 8 miles north of Terlingua."			
havardii		TEX	Powell/1397	3/20/66		TX	Presidio	"Road cut along Camino del Rio, ca. 5 miles south of Redford."			
havardii		LL	B.H.Warnock/13983	8/10/56		TX	Brewster	Terlingua area. Altitude 3000 feet.			
havardii		LL	C.L.Lundell/14764	9/14/47		TX	Brewster	Near Terlingua.			
havardii		LL	L.C.Hinckley/1631	6/10/41		TX	Presidio	About 2 mi. S of county line.			
havardii		TEX	B.H.Warnock/17766	3/27/59		TX	Presidio	Lower slopes of Chinati Peak; altitude 4600 feet.			
havardii		LL	D.S.Correll/18353	7/22/57		TX	Brewster	"At mouth of Terlingua Creek, Big Bend National Park."			
havardii		LL	D.S.Correll/18364	7/22/57		TX	Brewster	"On Terlingua Flats near Study Butte, Big Bend National Park."			
havardii		LL	D.S.Correll/19406	7/7/58		TX	VAL VERDE	Few plants on talus in Pump Canyon near Langtry.			
havardii		TEX	A.M.Powell/1981	7/2/70		TX	Brewster	Ca. 65 mi. S of Alpine.			
havardii		LL	D.S.Correll/20659	4/2/59		TX	Brewster	"About 4 miles north of Tornillo Creek, route #51, Big Bend National Park."			

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havardii		TEX	B.L.Turner/21-108	3/23/01		TX	Brewster	Ca. 0.5 mi. S of Turners Valentine Section ca. 58 mi. S of Alpine along highway 118; on and about -Turners Nipple+. Alt. 3330 ft.		29.533	102.433
havardii		TEX	B.L.Turner/21-89	3/23/01		TX	Brewster	"Ca. 0.5 mi. S of Turners Valentine Section, ca. 58 mi. S of Alpine along highway 118; on and about -Turners Nipple+."		29.533	102.433
havardii		TEX	B.H.Warnock/21749	8/6/41		TX	Brewster	Blackbrush Gap.			
havardii		LL	D.S.Correll/21901	5/14/59		TX	Presidio	10 miles southeast of Redford.			
havardii		LL	A.Traverse/2241	5/13/61		TX	Brewster	"Big Bend National Park, 17.9 mi. S of Panther Jct. Rd., on Boquillas Canyon Rd. Altitude: 2000 feet."			
havardii		LL	D.S.Correll/23612	4/17/61		TX	Brewster	"On hills near bridge over lower Tornillo Creek, Big Bend National Park."			
havardii		LL	D.S.Correll/23626	4/18/61		TX	Brewster	"Oak Creek, on road to Terlingua from basin, Big Bend National Park."			
havardii		LL	D.S.Correll/23627	4/18/61		TX	Brewster	"Oak Creek, on road to Terlingua from basin, Big Bend National Park."			
havardii		LL	D.S.Correll/27852	6/16/63		TX	Brewster	On road to Agua Frio Ranch from hwy. #118; 60 miles south of Alpine.			

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havardii		LL	D.S.Correll/32646	4/22/66		TX	Brewster	"Mouth of Tornillo Creek at Hot Springs, Big Bend National Park."			
havardii		TEX	M.Butterwick/3697	5/22/77		TX	Brewster	"San Francisco Canyon, ca. 4 miles up from the Rio Grande. Ca. 18 miles S of Sanderson."			
havardii		TEX	D.O.Kolle/387	2/25/77		TX	Brewster	Terlingua creek bridge at Hwy. Dept. station.			
havardii		TEX	V.L.Cory/39744	8/19/42		TX	Val Verde	Rio Grande bottoms at Del Rio.			
havardii		TEX	V.L.Cory/44010	3/31/44		TX	Brewster	Hot Springs.			
havardii		TEX	A.Nelson/5044	4/2/42		TX	Brewster	"Near Terlingua, Texas."			
havardii		TEX	B.H.Warnock/531	3/19/41		TX	Brewster	7 miles north of Terlingua Creek on road to Alpine.			
havardii		LL	B.H.Warnock/7579	9/28/47		TX	Brewster	Along Terlingua-Lajitas highway; 10 miles from Rio Grande; alt. 3500 feet.			
havardii		TEX	R.McVaugh/7966	4/16/47		TX	Presidio	"Bottom of narrow draw above Rio Grande, 3 miles north of Candelaria."			
havardii		LL	A.S.Barclay/807	6/14/60		TX	Brewster	Tornillo Creek; Big Bend National Park.			

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havardii		TEX	M.Turner/83	3/20/99		TX	Brewster	"Ca. 8 airmiles NNE of Study Butte at Ament Lake, along Ament Lake road, 1.7 miles E of TX 118 at the Terlingua Ranch gate entrance #9, 8.1 miles N of jct. of TX 118 & FM 170 at Study Butte."		29.533	102.633
havardii		TEX	M.Butterwick/850	6/7/75		TX	Brewster	Just northeast of Eagle Peak in the Solitario on the Big Bend Ranch.			
havardii		TEX	B.C.Tharp/8823	6/20/31		TX	Brewster	"Hot Springs, Texas."			
havardii		TEX	B.H.Warnock/897	6/26/37		TX	Brewster	"South of Talley Mt., Chisos Mts."			
havardii		TEX	B.B.Simpson/92-06-23-3	6/23/92		TX	Brewster	Route 170 ca. 27 road miles W of Terlingua. 878 m. elevation.		29.319	102.346
havardii		TEX	B.L.Turner/99-12	3/8/99		TX	Brewster	71 mi. south of Alpine.		29.467	102.433
havardii		TEX	B.H.Warnock/C308	4/3/38		TX	Brewster	"Above Hot Springs, Chisos Mt. area."			
havardii		TEX	V.L.Cory/s.n.	4/2/39		TX	Terrell	"Dryden, Texas."			
havardii		TEX	B.H.Warnock/s.n.	2/14/37		TX	Brewster	Along Tornillo Creek at Hot Springs. Chisos Mountains area.			
havardii		TEX	B.H.Warnock/s.n.	7/17/37		TX	Brewster	"Comanche Spring near Lajitas, Texas. Chisos Mountain area."			

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hintoniora		TEX	C.P.Cowan/3571	1992	Mex.	COA	SALTILLO	San Lorenzo Ca±?n 5.1 Km (3.2 mi) en terracer?a de la carr Saltillo a Zacatecas (54). 1 hora a pie arriba en el ca±?n.		25.338	-100.975
hintoniora		TEX	J.A.Villarreal/2363	1983	Mex.	NL	SANTIAGO	Ca±?n La Boca.		25.428	-100.115
hintoniora		TEX	C.P.Cowan/2765	1982	Mex.	NL	GALEANA	Pablillo 2.6 mi al SW.		24.571	-100.015
hintoniora		TEX	T.F.Patterson/6344	1988	Mex.	NL	MONTEMORELOS	La Trinidad (Nuevo Leon - MONTEMORELOS)		25.231	-100.089
hintoniora		TEX	G.Nesom/7455	1994	Mex.	NL	Hidalgo	El Mimbre arroyo		25.935	-100.473
hintoniora		TEX	G.B.Hinton/21521	1991	Mex.	NL	GALEANA	R?o de San Jos? nr (Nuevo Leon - GALEANA)		24.597	-99.888
hintoniora		TEX	G.B.Hinton/21665	1991	Mex.	NL	ITURBIDE	Iturbide 13.71 Km al S carr a La Pur?sima.		24.633	-99.825
hintoniora		TEX	G.B.Hinton/25838	1996	Mex.	NL	GALEANA	Entre Ci?nega del Toro y Santa Rosa		25.088	-100.267
hintoniora		TEX	G.B.Hinton/25846	1996	Mex.	NL	GALEANA	Entre Ci?nega del Toro y Santa Rosa		25.088	-100.267
hintoniora		TEX	B.L.Westlund/5.20.88.3	1988	Mex.	NL	GENERAL ZARAGOZA	Zaragoza 0.6 mi al S camino a La Encantada.		23.969	-99.773
hintoniora		TEX-type	G.B.Hinton/	1990	Mex.	NL	ARAMBERRI	Aramberri N		24.099	-99.817
hintoniora		TEX	G.B.Hinton/995	1994	Mex.	TAM	Hidalgo	Miradores (Tamaulipas - Hidalgo)		24.047	-99.314
hirsuta		NY	L.O.Williams/22008	29 Nov 1962	Guat.	HUE		Sierra de los Cuchumatanes just below Calaveras, Department of Huehuetenango	3000		

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hirsuta		NY	L.O.Williams/25877	13 Dec 1963	Guat.	SM		Sierra Madre Moutains about 6 km (airline) north of San Marcos, dept. San Marcos	2700		
hirsuta		NY	J.A.Steyermark/47212	7 Jun 1942	Guat.	SOL		Vocan San Pedro, north-facing slopes towards Lago de Atitlan, above village of San Pedro	1800		
hirsuta		GH	C.G.Pringle/1441	27 May 1906	Mex.	OAX					
hirsuta		GH	C.Conzatti/191	26 Apr 1896	Mex.	OAX					
hirsuta		GH	C.Conzatti/206	24 May 1896	Mex.	OAX					
hirsuta		MO	D.E.Breedlove/35947	4 Nov 1973	Mex.	OAX		North of Jayacatlan along road towards Nacaltepec	1600		
hirsuta		TEX	F.R.Barrie/410	1982	Mex.	OAX	SAN BARTOLO COYOTEPEC	La Guelavaca (El Tule); 16 km N por la carretera federal libre no. 175		17.058	-96.690
hirsuta		GH	C.G.Pringle/4791	13 Aug 1894	Mex.	OAX					
hirsuta		NY	C.G.Pringle/4791	13 Aug 1894	Mex.	OAX		Sierra de San Felipe	500		
hirsuta		LL, TEX	J.L>Panero/5826	8 Sep 1995	Mex.	OAX	Tlacolula	Diaz Ordaz. 18 km al N de Diaz Ordaz sobre la carretera a Cuajimoloyas.	2300	17.103	95.534
hirsuta		NY	C.L.Smith/818	2 Oct 1894	Mex.	OAX		Sierra de San Felipe	2300		
hirsuta		GH	illeg?/15237	Jun 1942	Mex.						
hirsuta		GH	C.Conzatti/293	8 Aug 1897	USA	OAX					
hirsuta		GH	/								
hispida	hispida	GH	I.L.Wiggins/15802	18 Mar 1960	Mex.	BC		15 miles south of San Felipe			

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hispida	hispida	GH	R.W.Cruden/1245	3 Sep 1966	Mex.	CHI					
hispida	hispida	GH	E.W.Nelson/6436	20-21 Sep 1899	Mex.	CHI					
hispida	hispida	GH	R.M.Stewart/700	6 Jul 1941	Mex.	CHI					
hispida	hispida	GH	I.M.Johnston/8158	11-12 Aug 1941	Mex.	CHI					
hispida	hispida	GH	H.LeSueur/Mex-311	10 Oct 1935	Mex.	CHI					
hispida	hispida	GH	E.G.Marsh/1595	20 Apr 1939	Mex.	COA					
hispida	hispida	GH	G.B.Hinton/16782	1 May 1949	Mex.	COA					
hispida	hispida	GH	S.S.White/1986	24 Jul 1939	Mex.	COA					
hispida	hispida	GH	E.G.Marsh/2101	12 Apr 1936	Mex.	COA					
hispida	hispida	GH	R.M.Stewart/3003	13 Oct 1942	Mex.	COA					
hispida	hispida	GH	R.M.Stewart/434	12 Jun 1941	Mex.	COA					
hispida	hispida	GH	E.Palmer/458	13-20 Oct 1898	Mex.	COA					
hispida	hispida	GH	A.H.Schroeder/5	27 Apr 1941	Mex.	COA		Canon Espantosa, western slope of Sierra de San Vicente; a large canyon in limestone about 20 km E. SE. of Cuatro Cienegas.			
hispida	hispida	GH	I.M.Johnston/744A	26 Aug 1940	Mex.	COA					
hispida	hispida	GH	E.Palmer/84	15-30 Apr 1898	Mex.	COA					
hispida	hispida	GH	E.Palmer/84 1/2	15-30 Apr 1898	Mex.	COA					
hispida	hispida	GH	I.M.Johnston/8582	28 Aug 1941	Mex.	COA					
hispida	hispida	GH	E.Palmer/859	Feb to	Mex.	COA					

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				Oct 1880							
hispida	hispida	GH	I.M.Johnston/9265	19 Sep 1941	Mex.	COA					
hispida	hispida	GH	C.G.Pringle/87	18 Mar 1885	Mex.	DUR		plains mapimi (?)			
hispida	hispida	GH	W.M.Canby/169	18 Mar 1900	Mex.	MONT					
hispida	hispida	GH	W.M.Canby/169	18 Mar 1900	Mex.	MONT					
hispida	hispida	GH	anon/1071?	Jun 1843	Mex.	NL					
hispida	hispida	GH	G.L.Webster/11165	6 Jun 1962	Mex.	NL					
hispida	hispida	GH	F.W.Pennell/16778	17 Jun 1934	Mex.	NL					
hispida	hispida	GH	J.N.Weaver/576	6 Jun 1942	Mex.	NL					
hispida	hispida	GH	C.A.Purpus/4861	Nov 1910	Mex.	SLP					
hispida	hispida	GH	C.C.Parry/608	1878	Mex.	SLP					
hispida	hispida	GH	J.N.Rose/13409	Mar 191x	Mex.	SIN		San Blas			
hispida	hispida	GH	C.Lisencholz/18	21 Feb 1910	Mex.	SON		Charco, Sierra Blanco, south of Sonoyta (Sonora?)			
hispida	hispida	GH	S.S.White/2940	11 Jul 1940	Mex.	SON		Horconcitos, Rio Huanchinera			
hispida	hispida	GH	S.S.White/444	6 Jul 1938	Mex.	SON		Colonia Oaxaca			
hispida	hispida	GH	G.Thurber/448	Jun 1851	Mex.	SON		Fronteras			
hispida	hispida	GH	C.V.Hartman/61	4 Oct 1890	Mex.	SON		Cochuto			
hispida	hispida	GH	J.Arguelles/79	May 1959	Mex.	SON		San Bernardo & vicinity, Rio Mayo watershed	400		
hispida	hispida	GH	G.Thurber/972	Sep 1851	Mex.	SON		illeg.			

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hispida	hispida	GH	C.H.Ramos/181	16 May 1968	Mex.	VER		En laderas de pequenas elevacdiones en la orilla del camino la gloria a unos 2 km. de total comapa 36.5 22.5			
hispida	hispida	GH	I.M.Johnston/7470	7 Sep 1938	Mex.	ZAC					
hispida	hispida	GH	C.Wright/1586	1851-52	Mex.						
hispida	hispida	GH	Gregg (?)/s.n.	14-15 Apr '47 (1847?)	Mex.						
hispida	hispida	GH	S.L.Glowenke/10864	16 Apr 1948	USA	AZ	Pinal	along Rt. 80-89, Bogard Wash			
hispida	hispida	GH	L.J.Brass/14339	8 May 1940	USA	AZ		Tanque Verde Canyon, 16 mi E. of Tucson	840		
hispida	hispida	GH	W.F.Parish/157	2 May 1884	USA	AZ		Plains. Lowell			
hispida	hispida	GH	E.Palmer/188	Apr 1867	USA	AZ					
hispida	hispida	GH	W.W.Eggleston/19877	8 May 1924	USA	AZ	Graham	Tanque	1200		
hispida	hispida	GH	E.L.Greene/459	1 Nov 1880	USA	AZ					
hispida	hispida	GH	H.C.Cutler/4718	27 Apr 1941	USA	AZ		12 miles south of Casa Grande,	400		
hispida	hispida	GH	L.H.Bailey/10037	8 Apr 1927	USA	CA	Riverside	Chuckawalla Pass			
hispida	hispida	GH	L..Abrams/14008	11 May 1941	USA	CA	San Bernardino	Larrea belt 17 miles east of Yermo on US Highway #91. Mojave Desert			
hispida	hispida	GH	P.A.Munz/15686	23 Mar 1940	USA	CA	Riverside	north part of Pinto Basin	610		
hispida	hispida	GH	J.G.Lemmon/164	1880	USA	CA		Mohave Desert			
hispida	hispida	GH	M.F.Spencer/2045	30 Mar 1922	USA	CA		around Dos Palmas, Colorado Desert			

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hispida	hispida	GH	F.W.Pennell/25016	31 Mar 1940	USA	CA	Riverside	12 mi. w. of Blythe	370		
hispida	hispida	GH	E.A.Mearns/2881	9 Apr 1894	USA	CA		Seven Wells, Salton River, Lower California			
hispida	hispida	GH	C.B.Wolf/3218	1 May 1932	USA	CA	San Bernardino	Eastern Colorado Desert. Hanks well, Vidal to Needles	300		
hispida	hispida	GH	O.B.Metcalfe/1145(?)	13 Jul 1904	USA	NM	Sierra	Animas Creek (?)	1500		
hispida	hispida	GH	O.B.Metcalfe/143	15 Jun 1903	USA	NM	Grant				
hispida	hispida	GH	K.M,Wiegand/1818	11 Apr 1935	USA	NM	Santa Ana	mountain pass, Alamogordo to Las Cruces			
hispida	hispida	GH	U.T.Waterfall/3741	13 Aug 1942	USA	NM	Eddy				
hispida	hispida	GH	illegRothrock/445	Aug 1874	USA	NM					
hispida	hispida	GH	S.D.McKelvey/4605	23 May 1934	USA	NM	McKinley	Road to Mariano Lake, n.e. of Gallup			
hispida	hispida	GH	F.R.Fosberg/53655	13 Aug 1930	USA	NM	Dona Ana				
hispida	hispida	GH	E.O.Wooton/s.n.	Apr 1892	USA	NM	Mesa				
hispida	hispida	GH	B.B.Brues/	1927?	USA	NM					
hispida	hispida	GH	G.W.Stevens/1044	19 Jun 1913	USA	OK	Harmon				
hispida	hispida	GH	DelzieDemaree/13025	19 Jun 1936	USA	OK	Comanche				
hispida	hispida	GH	G.J.Goodman/5723	1 jul 1953	USA	OK	Johnston				
hispida	hispida	GH	W.H.Emig/905	28 Jun 1917	USA	OK					
hispida	hispida	GH	Lindheimer/1009	May 1850	USA	TX					
hispida	hispida	GH	R.R.Innes/1053	12 Jun 1941	USA	TX	Lynn				
hispida	hispida	GH	R.R.Innes/1304	22 Jun	USA	TX	Dimmit				

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				1941							
hispida	hispida	GH	V.L.Cory/13803	20 May 1935	USA	TX	Andrews				
hispida	hispida	GH	V.L.Cory/14207	7 Jun 1935	USA	TX	Brooks				
hispida	hispida	GH	V.L.Cory/14897	22 Jun 1935	USA	TX	Uvalde				
hispida	hispida	GH	V.L.Cory/15117	24 Jun 1935	USA	TX	Wilson				
hispida	hispida	GH	V.L.Cory/15308	19 Jul 1935	USA	TX	Tom Green				
hispida	hispida	GH	C.Wright/1585-136	1851	USA	TX	Val Verde				
hispida	hispida	GH	F.P.Pennell/16778 (dup)	17 Jun 1934	USA	TX	Travis				
hispida	hispida	GH	K.M.Wiegand/1812	6 Apr 1935	USA	TX	Brewster				
hispida	hispida	GH	K.M.Wiegand/1816	6 Apr 1935	USA	TX	Brewster	Calamity Creek, 19 miles south of Alpine			
hispida	hispida	GH	V.L.Cory/18339	9 Apr 1936	USA	TX	Crockett				
hispida	hispida	GH	D.S.Correll/19730	17 Jul 1958	USA	TX	Duval				
hispida	hispida	GH	V.L.Cory/20394	19 Sep 1936	USA	TX	Aransas				
hispida	hispida	GH	D.S.Correll/22114	18 May 1959	USA	TX	Kent				
hispida	hispida	GH	L.C.Hinckley/2359	7 Feb 1942	USA	TX	Presidio	In moist soil near Torneros Creek at Casa Piedra-Redford crossing about 65 mi. S. Marfa	1000		
hispida	hispida	GH	G.L.Webster/3009	23 Jun 1950	USA	TX	Goliad				
hispida	hispida	GH	Drummond?/309		USA	TX					
hispida	hispida	GH	D.S.Correll/32645	22 Apr 1966	USA	TX	Brewster				
hispida	hispida	GH	J.A.Moore/3268	27 Jun 1931	USA	TX	Brewster				
hispida	hispida	GH	D.S.Correll/38611	2 May	USA	TX	El Paso				

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
				1970							
hispida	hispida	GH	U.T.Waterfall/3872	15 Aug 1942	USA	TX	Hudspeth				
hispida	hispida	GH	U.T.Waterfall/3949	17 Aug 1942	USA	TX	El Paso				
hispida	hispida	GH	U.T.Waterfall/4001	18 Aug 1942	USA	TX	Hudspeth				
hispida	hispida	GH	U.T.Waterfall/4166	21 Aug 1942	USA	TX	Culberson				
hispida	hispida	GH	B.C.Tharp/42-37	11 Jul 1941	USA	TX	Crane				
hispida	hispida	GH	B.C.Tharp/43-782B	15 Jun 1943	USA	TX	Pecos				
hispida	hispida	GH	U.T.Waterfall/4453	11 Jun 1943	USA	TX	Culberson				
hispida	hispida	GH	U.T.Waterfall/4603	18 Jun 1943	USA	TX	Hudspeth				
hispida	hispida	GH	U.T.Waterfall/4631	21 Jun 1943	USA	TX	Culberson				
hispida	hispida	GH	J.W.Gillespie/5245	9 Jun 1931	USA	TX	Reeves				
hispida	hispida	GH	V.L.Cory/53812	29 May 1947	USA	TX	Hamilton				
hispida	hispida	GH	Mrs. E.J.Walker/6	2 Feb 1942	USA	TX		La Jaya			
hispida	hispida	GH	U.T.Waterfall/6649	21 Aug 1946	USA	TX	El Paso				
hispida	hispida	GH	B.F.Bush/669	8 May 1900	USA	TX					
hispida	hispida	GH	W.L.Tolstead/7322	28 May 1943	USA	TX	Taylor				
hispida	hispida	GH	R.VcVaugh/7948	16 Apr 1947	USA	TX	Presidio				
hispida	hispida	GH	A.Ruth/886	26 May 1922	USA	TX	Tarrant				
hispida	hispida	GH	B.H.Warnock/895	10 Jun 1937	USA	TX	Chisos				
hispida	hispida	GH	C.L.Lundell/9109	25 May 1940	USA	TX	Bastrop				
hispida	hispida	GH	V.L.Cory/9634	15 Aug 1934	USA	TX	Jeff Davis				
hispida	hispida	GH	N.T.Kidder/s.n.	illeg	USA	TX					

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
				1885							
hispida	hispida	GH	B..Tharp/s.n.	10 Jul 1941	USA	TX					
hispida	hispida	GH	B.C.Tharp/s.n.	10 May 1937	USA	TX	Travis				
hispida	hispida	GH	B.C.Tharp/s.n.	13 Jun 1941	USA	TX	Stephens				
hispida	hispida	GH	B.C.Tharp/s.n.	15 Jun 1939	USA	TX	Travis				
hispida	hispida	GH	B.C.Tharp/s.n.	20 Jul 1940	USA	TX	Travil				
hispida	hispida	GH	F.Lindheimer/	1843	USA	TX					
hispida	hispida	GH	Berlandier/	Apr 1834	USA	TX		De Matamoros a Goliad			
hispida	hispida	GH	C.Wright/493	May-Oct 1849	USA						
hispida	hispida	GH	C.Wright/494	May-Oct 1849	USA						
hispida	hispida	GH	C.Wright/495	May-Oct 1849	USA						
hispida	hispida	GH	M.Riedel/s.n.	18 Jul 1941	USA		DeWitt				
hispida	hispida	GH	C.Wright/1585	1851-52							
hispida	hispida	GH	C.Wright/1586	1851-52							
hispida	hispida	GH	Berlandier?/2443=1013	Jul 1834							
hispida	hispida	GH	J.M.Bigelow/979	10 Oct 1853				illeg.			
hispida	hispida	GH	A.Gray/								
hispida	hispidium	GH	E.O.Wooton/27	17 Jun 1897	USA	NM	Dona Ana				
hispida	mentzelii	TEX	M.A.Baker/8481	8 Jun 1991	USA	AZ	Gila				
hispida	peninsulare	GH	I.M.Johnston/3674	13 May 1921	Mex.	BC		Mulege			
hispida	sonorae	GH	E.A.Goldman/310	12 Feb 1899	Mex.	SIN					
hispida	sonorae	GH	H.S.Gentry/7009	14 Mar 1944	Mex.	SIN					
hispida	sonorae	GH	H.S.Gentry/7009a	14 Mar	Mex.	SIN					

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
				1944							
hispida	sonorae	TEX	A.T.Whittemore/	1983	Mex.	SON	ND	4.7 mi NE of Esperanza Hwy 11 (jct Hwy 15) at turnout to gravel pit (on N side) S of Hornos		27.650	-109.900
hispida	sonorae	TEX	R.S.Felger/	1963	Mex.	SON	PITIQUITO	Pozo Coyote 10 mi E of Pozo Coyote (NE of El Desemboque y arroyo San Ignacio)		29.635	-112.214
hispida	sonorae	TEX	A.C.Sanders/	1993	Mex.	SON	ALAMOS	Rd-side ca 12 Km W of Alamos on the rd to Navojoa vicinity of Ca±on Agua Martina at the foot of the Sa de Alamos		27.033	-109.083
hispida	sonorae	TEX	A.C.Sanders/	1993	Mex.	SON	HUATABAMP O	Bachoco 7.3 Km S and just S of Arroyo Bajerobeta Mate Mula a fishing camp on the coast SE of Yavaros		26.682	-109.360
hispida	sonorae	TEX	A.T.Whittemore/	1983	Mex.	SON	ND	13 mi NE of Hornos 23.4 mi SW of Tezopaco (ca 40 Km NE of Cd Obreg?n)		27.750	-109.750
hispida	spathulata	GH	W.P.Hewitt/100	16 Fe 1946	Mex.	CHI					
hispida	spathulata	GH	E.Palmer/106	8-27 Apr 1908	Mex.	CHI					
hispida	spathulata	GH	R.M.Stewart/2225	5 Mar 1942	Mex.	CHI					
hispida	spathulata	GH	E.Palmer/238	15-17 May 1908	Mex.	CHI					
hispida	spathulata	GH	E.A.Goldman/410	15 May 1899	Mex.	CHI					

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
hispida	spathulata	GH	C.V.Hartman/643	10 Apr 1891	Mex.	CHI					
hispida	spathulata	GH	E.A.Goldman/s.n.	15 May 1899	Mex.	CHI					
hispida	spathulata	GH	J.C.Johnson/15215 M	28 Feb 1946	Mex.	COA					
hispida	spathulata	GH	C.A.Purpus/1874	Mar 1905	Mex.	COA					
hispida	spathulata	GH	R.M.Stewart/2247	13 Mar 1942	Mex.	COA					
hispida	spathulata	GH	C.G.Pringle/9011	15 Apr 1900	Mex.	COA					
hispida	spathulata	GH	J.T.Painter/14282	27 Feb 1944	Mex.	NL					
hispida	spathulata	GH	anon/160 ex 2	Feb 1828	Mex.	TAM					
hispida	spathulata	GH	C.Wright/1585-105(?)	1851-52	Mex.						
hispida	spathulata	GH	L.J.Brass/14308	8 Apr 1940	USA	AZ					
hispida	spathulata	GH	K.M.Wiegand/1820	19 Apr 1935	USA	AZ	Pima				
hispida	spathulata	GH	R.C.Foster/190	16 Apr 1938	USA	AZ	Cochise				
hispida	spathulata	LL	J.Ingram/229	26 Apr 1955	USA	AZ	Maricopa				
hispida	spathulata	TEX	C.L.Hitchcock/25714	18 Mar 1970	USA	AZ	Yuma				
hispida	spathulata	GH	V.L.Cory/3354	27 Apr 1930	USA	AZ					
hispida	spathulata	GH	J.W.Gillespie/5599	9 Apr 1932	USA	AZ	Maricopa				
hispida	spathulata	TEX	A.Cronquist/9953	8 May 1964	USA	AZ	Mohave				
hispida	spathulata	GH	A.Cronquist/9953	8 May 1964	USA	AZ	Mohave				
hispida	spathulata	GH	C.G.Pringle/s.n.	Apr 1881	USA	AZ					
hispida	spathulata	GH	F.Shreve/10255	7 Apr 1941	USA	NM	Eddy				
hispida	spathulata	GH	A.Nelson/11439a	24 May 1931	USA	NM					
hispida	spathulata	GH	G.Thurber/301	Apr 1851	USA	NM					

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hispida	spathulata	GH	A.Fendler/643	1847	USA	NM					
hispida	spathulata	GH	Mrs. J.Clemens/11741	18 May 1916	USA	OK	Comanche				
hispida	spathulata	GH	O.E.Sperry/1671	10 Mar 1940	USA	TX	Brewster				
hispida	spathulata	GH	H.B.Parks/18027	14 Mar 1936	USA	TX	Hidalgo				
hispida	spathulata	GH	V.L.Cory/18341	9 Apr 1936	USA	TX	Pecos				
hispida	spathulata	GH	V.L.Cory/18710	14 Apr 1936	USA	TX	Brewster				
hispida	spathulata	GH	V.L.Cory/18758	s.d.	USA	TX	Pecos				
hispida	spathulata	GH	S.D.McKelvey/1i898	19 Apr 1931	USA	TX	Val Verde				
hispida	spathulata	GH	E.D.Schulz/235	Aug 1920	USA	TX					
hispida	spathulata	GH	L.C.Hinckley/2389	21 Feb 1942	USA	TX	Presidio				
hispida	spathulata	GH	L.C.Hinckley/2900	4 Mar 1944	USA	TX	Presidio				
hispida	spathulata	GH	Drummond?/309 (or, III?)	1835	USA	TX					
hispida	spathulata	GH	D.S.Correll/38330	6 Apr 1970	USA	TX	El Paso				
hispida	spathulata	GH	H.C.Hanson/388	17 Mar 1919	USA	TX					
hispida	spathulata	GH	J.Reverchon/3892	19 Mar 1903	USA	TX					
hispida	spathulata	GH	U.T.Waterfall/4402	8 Jun 1943	USA	TX	Jeff Davis				
hispida	spathulata	GH	A.Nelson/5003	31 Mar 1942	USA	TX					
hispida	spathulata	GH	R.R.Innes/510	19 Mar 1941	USA	TX	Brewster				
hispida	spathulata	GH	R.R.Innes/528	19 Mar 1941	USA	TX	Brewster				
hispida	spathulata	GH	H.C.Benke/5414	11 Apr 1930	USA	TX					
hispida	spathulata	GH	V.L.Cory/624	30 Apr 1929	USA	TX	illeg				
hispida	spathulata	GH	S.M.Tracy/65	14 Apr 1902	USA	TX					

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hispida	spathulata	GH	R.McVaugh/7960	16 Apr 1947	USA	TX	Presidio				
hispida	spathulata	GH	V.L.Cory/s.n.	6 May 1928	USA	TX	Brewster				
hispida	spathulata	GH	G.L.Fisher/s.n.	21 Apr 1941	USA	TX					
hispida	spathulata	GH	L.C.Hinckley/s.n.	Mar 1937	USA	TX	Presidio				
hispida	spathulata	GH	B.C.Tharp/s.n.	16 May 1939	USA	TX	Travis				
hispida	spathulata	GH	C.Wright/s.n.	1850	USA	TX					
hispida	spathulata	GH	C.Wright/s.n.		USA	TX					
hispida	spathulata	GH	D.W.Matthews/44	1882							
hispida	spathulata	GH	A.Fendler/643	1847							
hispida	tenue	GH	E.L.Greene/1291	6 Sep 1904	USA	NM	Sierra	3 miles S of Hillsboro; in and around the south end od the Black Range	1500		
hispida		TEX	H.LeSueur/311	1936	Mex.	CHI	Chihuahua	Chihuahua		28.635	-106.089
hispida		LL	R.M.Stewart/700	1941	Mex.	CHI	Chihuahua	Rancho Encinillas		29.223	-106.383
hispida		LL	Ellis/922	1975	Mex.	CHI	ND	9.5 mi up Piedras Verdes on Rancho Los Nogales. In Sa La Brena on the Sa Madre Occidental		30.328	-108.189
hispida		TEX	R.W.Cruden/1245	1966	Mex.	CHI	JU?REZ	Rte 45 between km 1982 and 1983 ca 4 km S of Samalayuca		31.310	-106.491
hispida		LL	B.Marcks/1283	1969	Mex.	CHI	Chihuahua	N edge of Chihuahua along Hwy 45 by Santa Rita Motel		28.635	-106.089
hispida		TEX	A.M.Powell/1988	1971	Mex.	CHI	OJINAGA	Manuel Ojinaga		29.482	-104.414
hispida		TEX	A.M.Powell/2020	1971	Mex.	CHI	OJINAGA	Manuel Ojinaga		28.805	-104.468

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hispida		TEX	A.M.Powell/2024	1971	Mex.	CHI	ALDAMA	Near Hwy 16 27.3 mi NE of Aldama on rd to new lake on R?o Conchos		29.060	-105.605
hispida		LL	A.F.Moldenke/2081	1967	Mex.	CHI	AHUMADA	Miguel Ahumada		29.999	-106.375
hispida		LL	A.M.Powell/2460	1973	Mex.	CHI	OJINAGA	Manuel Ojinaga		29.545	-104.693
hispida		TEX	G.Nesom/5464	1986	Mex.	CHI	AHUMADA	22.5 mi S of El Sueco on Hwy 45		29.592	-106.353
hispida		LL	F.Chiang C/8335	1972	Mex.	CHI	CAMARGO	Torre de Microondas La Cruz aproximadamente 26 km N Santa Rosalia de Camargo (Camargo)		27.913	-105.197
hispida		LL	F.Chiang C/8369	1972	Mex.	CHI	ND	5 Km NE of Puerto de C?mes which is at the N end of the Sa de G?mez		28.983	-105.667
hispida		LL	F.Chiang C/9051	1972	Mex.	CHI	ND	9 Km NE of Carrillo toward Guimbalete N of railrd		26.944	-103.883
hispida		LL	F.Chiang C/9903	1972	Mex.	CHI	ND	8 Km E of Rancho Cieneguillas (across R?o Grande from S half of Eagle Mts of Hudspeth Co. Texas) by winding rd to Boquillas		30.742	-105.158
hispida		LL	M.C.Johnston/10539	1973	Mex.	CHI	ND	29.5 Km N of the Camargo-Jim?nez Hwy rd to La Perla; and 8 Km S of Restaurante El Herradero		27.808	-104.833

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hispida		LL	M.C.Johnston/10575	1973	Mex.	CHI	ND	Ca 20 Km NE of Coyame on the Ojinaga Hwy at Canotia Creek		29.550	-104.925
hispida		LL	M.C.Johnston/12409	1975	Mex.	CHI	ND	Bofecillas Canyon of R?o Grande NE of Sa del Mulato		28.283	-108.333
hispida		LL	D.S.Correll/21515	1959	Mex.	CHI	Hidalgo DEL PARRAL	Hidalgo del Parral		26.977	-105.482
hispida		LL	D.S.Correll/21524	1959	Mex.	CHI	Hidalgo DEL PARRAL	Hidalgo del Parral		26.977	-105.482
hispida		LL	D.S.Correll/21655	1959	Mex.	CHI	NUEVO CASAS GRANDES	3-5 mi SE of Nuevo Casas Grandes		30.373	-107.877
hispida		LL	D.S.Correll/21729	1959	Mex.	CHI	Chihuahua	Hwy 45 several mi W of Encinillas Village		29.262	-106.344
hispida		LL	D.S.Correll/21455-A	1959	Mex.	CHI	JIM?NEZ	Escal?n 10 mi NW sobre la carretera Libre Federal No. 49 (pavim. 2 carriles)		26.837	-104.473
hispida		LL	D.S.Correll/21455-B	1959	Mex.	CHI	JIM?NEZ	Escal?n 10 mi NW sobre la carretera Libre Federal No. 49 (pavim. 2 carriles)		26.837	-104.473
hispida		TEX	E.G.Marsh/137	1935	Mex.	COA	M?ZQUIZ	Ciudad de Melchor M·zquiz (M·zquiz)		27.878	-101.514
hispida		TEX	E.G.Marsh/137	1935	Mex.	COA	M?ZQUIZ	Ciudad de Melchor M·zquiz (M·zquiz)		27.878	-101.514
hispida		TEX	D.L.Latorre/153	1967	Mex.	COA	M?ZQUIZ	Melchor M·zquiz		27.877	-101.514
hispida		LL	R.M.Stewart/370	1941	Mex.	COA	ND	Vicinity of Santa Elena Mines calcareous Eern foothills of the Sa de las Cruces; 3 km SE of Santa Elena		26.340	-101.370

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hispida		LL	R.M.Stewart/434	1941	Mex.	COA	ND	Vicinity of Rancho El Tule S foothills of the igneous Sa Hechiceros; about 24 Km due N of Castillon and close to the Chihuahuan boundary		26.340	-101.370
hispida		TEX	P.A.Hernßndez/1057	1981	Mex.	COA	RAMOS ARIZPE	Carr Monterrey-Saltillo San Gregorio		25.640	-100.800
hispida		TEX	E.G.Marsh/1595	1939	Mex.	COA	ND	Hermanas		28.580	-101.604
hispida		TEX	E.M.Marsh/2101	1936	Mex.	COA	M?ZQUIZ	Ciudad de Melchor M·zquiz (M·zquiz)		27.878	-101.514
hispida		LL	R.M.Stewart/2247	1942	Mex.	COA	SIERRA MOJADA	Vicinity of Santa Elena Uno (Santa Elena) Mines E foothills of Sierra de Las Cruces		27.853	-102.979
hispida		LL	M.C.Johnston/7587	1972	Mex.	COA	ND	5 Km E Puerto de La Bufa		27.767	-102.717
hispida		TEX	F.Chiang C/7735	1972	Mex.	COA	ND	Central portion of plateau in Sa de los Alamitos 5.5 Km N of Australia		26.350	-102.317
hispida		LL	F.Chiang C/7794	1972	Mex.	COA	ND	8 Km NW of Viesca		25.383	-102.850
hispida		LL	I.M.Johnston/8582	1941	Mex.	COA	ND	Near Rancho Gallinas about 6 mi E of Puertecito		26.340	-101.370
hispida		LL	M.C.Johnston/10191	1973	Mex.	COA	ND	1 Km S of Rancho Las Cabras		26.958	-100.967
hispida		LL	M.C.Johnston/10313	1973	Mex.	COA	ND	15 Km N of Ejido La Noria on rd to La Campana and Cuatro Ci?negas		26.550	-101.725

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hispida		LL	M.C.Johnston/10389	1973	Mex.	COA	ND	Ca 1 Km W of Las Delicias at and near spring top of alluvial fan on side of Mt		26.233	-102.825
hispida		TEX	J.S.Wilson/10950	1966	Mex.	COA	SALTILLO	Guadalupe Victoria (3 m E of) on Monterrey to Zacatecas Hwy		25.001	-101.076
hispida		LL	M.C.Johnston/12382	1974	Mex.	COA	ND	Extreme NW part of State: Mariscal Canyon of R?o Grande 1 km downstream from entrance		28.983	-103.133
hispida		TEX	J.S.Henrickson/22086	1997	Mex.	COA	ND	Along Hwy between Hermanas (=Primero de Mayo) and San Buenaventura 3 mi NE of Abasolo in area with Boquillas Flag Shale		27.167	-101.400
hispida		LL	R.C.Rollins/58106	1958	Mex.	COA	SALTILLO	Saltillo 21 mi al E.		25.463	-100.689
hispida		TEX	M.C.Johnston/10371-B	1973	Mex.	COA	ND	10 Km SE of Las Margaritas on rd to Las Delicias		26.383	-102.833
hispida		TEX	M.C.Johnston/10374-B	1973	Mex.	COA	ND	About 10 Km NE of Las Delicias on the winding rd toward Las Margaritas		26.333	-102.817
hispida		TEX	J.C.Johnson/15215-M	1946	Mex.	COA	ND	23 mi SW of Monterrey		26.340	-101.370
hispida		GH	R.M.Stewart/2184	25 Oct 1941	Mex.	COA					

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hispida		TEX	D.L.Latorre/SN	1968	Mex.	COA	M?ZQUIZ	Ciudad de Melchor M·zquiz about 100 mi NW of Sierra Hermosa Rancho La Morada of Mr. And Mrs. Aldan McKellar		28.906	-102.543
hispida		GH	E.Palmer/860	Feb to Oct 1880	Mex.	COA					
hispida		TEX	J.L.Neff/92-3-15-1	1992	Mex.	DUR	TLAHUALILO	Reserva de la Bi?sfera de Mapim?		26.675	-103.750
hispida		TEX	J.L.Neff/92-3-16-3	1992	Mex.	DUR	ND	2 Km NE of La Flor		26.575	-103.941
hispida		GH	E.Palmer/854	Feb to Oct 1880	Mex.	MONT					
hispida		TEX	T.Bruni/37	1964	Mex.	NL	MONTERREY	Ciudad Monterrey 31 mi al W Hwy 40.		25.646	-100.771
hispida		LL	R.L.McGregor/129	1963	Mex.	NL	GALEANA	Galeana 2 mi al W Hwy 60.		24.819	-100.106
hispida		TEX	F.R.Barrie/375	1982	Mex.	NL	GALEANA	Pablillo 1 Km al N.		24.602	-99.995
hispida		LL	F.Chiang C/1700	1972	Mex.	NL	ND	66 Km S of San Roberto jct on rd to SLP		24.133	-100.367
hispida		TEX	G.Nesom/6219	1987	Mex.	NL	GALEANA	Near town of La Laguna ca 4 mi W of Galeana ca 1.6 mi S of lake in view of town		24.800	-100.102
hispida		TEX	J.S.Wilson/10821	1966	Mex.	NL	SABINAS Hidalgo	Ciudad Sabinas Hidalgo 14 mi S		26.312	-100.106
hispida		LL	M.C.Johnston/11205	1973	Mex.	NL	ND	59 Km N of San Roberto Jct on the Matehuala-Saltillo Hwy; 19 Km S of the Coahuila state line		25.100	-100.650
hispida		TEX	F.A.Barkley/14282	1944	Mex.	NL	MONTERREY	Ciudad Monterrey 12 mi al W.		25.692	-100.492

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hispida		TEX	F.A.Barkley/14346	1944	Mex.	NL	CHINA	China 12 mi al W.		25.718	-99.395
hispida		TEX	G.B.Hinton/19544	1989	Mex.	NL	GALEANA	El Aguililla		24.970	-100.561
hispida		TEX	G.B.Hinton/19636	1989	Mex.	NL	GALEANA	El Aguililla		24.970	-100.561
hispida		TEX	G.B.Hinton/21960	1992	Mex.	NL	ARAMBERRI	Puentes nr		24.145	-100.063
hispida		TEX	G.B.Hinton/24266	1994	Mex.	NL	MONTERREY	Ciudad Monterrey 110.235 Km al NE carr a Nuevo Laredo.		26.596	-99.971
hispida		TEX	G.B.Hinton/27579	2000	Mex.	NL	GALEANA	El Aguililla		24.970	-100.561
hispida		LL	R.C.Rollins/58101	1958	Mex.	NL	SANTA CATARINA	Ciudad Santa Catarina 5 mi al W.		25.696	-100.530
hispida		LL	M.C.Johnston/10226 -D	1973	Mex.	NL	ND	Puerto de Pedernales near the Estaci?n Microondas on Hwy 53		26.250	-100.683
hispida		LL	M.C.Johnston/10258 -B	1973	Mex.	NL	ND	Ca±?n de Potrerillos SW of mina de Los Blancos		26.067	-100.767
hispida		LL	M.C.Johnston/10262 -B	1973	Mex.	NL	ND	12 Km E of Rancho La Escondida just N of Rancho La Laguna		26.217	-101.017
hispida		TEX	G.L.Webster/14495- A	1944	Mex.	NL	SABINAS Hidalgo	Ciudad Sabinas Hidalgo 23 mi N carretera 41		26.826	-100.204
hispida		TEX	T.Alonis Jr./16171-M	1946	Mex.	NL	SANTA CATARINA	Ciudad Santa Catarina cerca de.		25.675	-100.462
hispida		TEX	T.Alonis Jr./16194-M	1946	Mex.	NL	SANTA CATARINA	Ciudad Santa Catarina cerca de.		25.675	-100.462
hispida		TEX	A.Hernßndez C./44M-824	1944	Mex.	NL	MONTERREY	R?o Santa Catarina.		25.663	-100.305
hispida		TEX	Chambers/SN	1935	Mex.	NL	MONTERREY	Ciudad Monterrey		25.671	-100.308
hispida		TEX	J.S.Wilson/12581	1967	Mex.	SLP	ND	Hwy 57 ca 6 Km N of Huizache jct		22.981	-100.471

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hispida		LL	J.Arguelles/79	1959	Mex.	SON	ALAMOS	San Bernardo & vicinity R?o Mayo watershed		27.400	-108.845
hispida		TEX	S.W.Sikes/160	1967	Mex.	SON	SOYOPA	Soyopa 2.4 mi N		28.798	-109.633
hispida		LL	S.S.White/2940	1940	Mex.	SON	BACERAC	Cienega de Horcones R?o Huachinera		30.204	-108.788
hispida		TEX	R.S.Felger/7606	1963	Mex.	SON	GENERAL PLUTARCO EL?AS CALLES	Sonoita 30.1 mi W on M?x Hwy 2		31.992	-113.309
hispida		TEX	H.Ibarra/105	1964	Mex.	TAM	NUEVO LAREDO	National Rd 85 10 mi SE of Nuevo Laredo		27.354	-99.569
hispida		TEX	J.T.Painter/14390	1944	Mex.	TAM	REYNOSA	20 mi W of Reynosa		26.207	-98.535
hispida		TEX	N.T.Heard/14586-B	1944	Mex.	TAM	NUEVO LAREDO	10 mi S of Nuevo Laredo		27.354	-99.570
hispida		LL	M.C.Johnston/10435-A	1973	Mex.	ZAC	ND	4 Km airline W of Rancho Nuevo		24.000	-101.667
hispida		TEX	I.Tidestrom/12357	11 Apr 1927	USA	AZ					
hispida		TEX	I.Tidestrom/12416	24 Apr 1927	USA	AZ					
hispida		LL	J.R.Crutchfield/1401	29 Apr 1966	USA	AZ	Cochise				
hispida		TEX	R.W.Matthews/479	31 Jul 1965	USA	AZ	Pima				
hispida		TEX	R.Irving/272	11 Jun 1964	USA	CO	Montezuma				
hispida		LL	J.Secor/10	9 Jun 1973	USA	NM					
hispida		LL,TEX	J.Secor/15	8 May 1970	USA	NM					
hispida		LL, TEX	S.Saufferer/192	22 May 1973	USA	NM	Socorro				
hispida		TEX	U.T.Waterfall/7287	27 Jun 1947	USA	OK	Cotton				
hispida		TEX	A.Graham/1	5/31/56	USA	TX	Brewster	"Rio Grande River, Santa Helena Canyon."			

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hispida		LL	G.L.Chamberlain/10	6/10/66	USA	TX	Brown	"16 miles north of Brownwood, Texas."			
hispida		TEX	G.L.Webster/100	5/22/49	USA	TX	TRAVIS	Sandy area on bank of Pedernales River west of Hamilton Pool.			
hispida		TEX	Lindheimer/1009		USA	TX	Comal	Comanche Spring: New Braunfels.			
hispida		LL	D.H.Riskind/1018		USA	TX	BREWSTER	Asa Jones+ Pumphouse on the Rio Grande. Elev. ca. 500 meters.			
hispida		LL	C.L.Lundell/10202	4/15/41	USA	TX	Pecos	"Off U. S. 290, 9 miles west of Ft. Stockton."			
hispida		TEX	S.L.Orzell/10389	6/7/89	USA	TX	Burleson	"Sandhill woodland-barrens on xeric unstable dunes, SW of FM 908. ca. 1.5 mi E of jct Co Rd 319, 0.7 air mi SW of Shiloh School & Cem., ca. 3.5 mi NW of jct TX 21, ca. 5.3 mi W of Caldwell; Chriesman 7.5+ Quad. Elev. 440-450 ft."		30.506	95.206
hispida		TEX	S.L.Orzell/10443	6/7/89	USA	TX	Milam	"Xeric sandhill woodland along FM 1786 (road to Alcoa plant), ca. 2.6 mi S of int US 79, ca. 6 mi. SW of Rockdale; Alcoa Lake 7.5+ Quad.; Elev. 520 ft."		30.598	96.924
hispida		TEX	R.R.Innes/1053	6/12/41	USA	TX	Lynn	17 miles south of Lubbock.			

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hispida		TEX	S.L.Orzell/10579	6/12/89	USA	TX	Williamson	"On county road 0.7 mi N of int. FM 112 at a point ca. 1.5 mi E of int. FM 486 at Shiloh, ca. 0.8 mi W of Milam Co line, ca. 9 mi S of Thorndale; Beaukiss 7.5+ Quad., Elev. 530 ft."		30.490	96.822
hispida		LL	B.Hutchins/1058	4/20/66	USA	TX	Garza	Sandy loam of playa lake 11.1 air miles northwest of Post. Elev. approx. 2950 ft.			
hispida		LL	C.M.Rowell/11174	4/8/67	USA	TX	Brewster	Black Gap Wildlife Management Area 57 miles south of Marathon.			
hispida		TEX	T.Wendt/1125	8/10/75	USA	TX	Howard	"Big Spring State Park, top of highest hill in park, just S of HQ; ca. 300 ft elev."		32.229	100.508
hispida		TEX	G.C.Williams/115	5/4/58	USA	TX	San Patricio	"Welder Wildlife Refuge, Sect 51."			
hispida		TEX	J.O.Parks/117	4/10/49	USA	TX	Terrell	20 miles east of Dryden.			
hispida		LL	C.L.Lundell/12770	4/6/44	USA	TX	Brooks	"Off U. S. highway 281, south of Encino."			
hispida		TEX	R. R. InnesInnes/1304	6/22/41	USA	TX	Dimmit	7 miles east of Big Wells.			
hispida		TEX	F.A.Barkley/13120	6/25/43	USA	TX	San Saba	13 miles southeast of San Saba.			

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hispida		TEX	A.Prather/1335	5/9/93	USA	TX	Guadalupe	"Along TX FM 1117, ca. 3.2 km W of Guadelupe/ Gonzales County line, near the intersection with County Place Road. "			
hispida		LL	C.L.Lundell/13613	4/21/45	USA	TX	Frio	"Off highway 85, 11 miles west of Dilley."			
hispida		LL	B.H.Warnock/13719		USA	TX	El Paso	5 miles west of Hueco - Hueco Mts.			
hispida		TEX	M.de Jesus Solis/138	3/23/63	USA	TX	Brooks	"State Highway 285, 13 miles east of Hebbronville."			
hispida		TEX	J.T.Painter/14420	2/29/44	USA	TX	Hidalgo	23 miles north of Edinburgh.			
hispida		LL	B.H.Warnock/14562	5/28/57	USA	TX	Presidio	Bogel ranch; three miles west of San Estaban Lake. Altitude 4100 feet.			
hispida		LL	B.H.Warnock/14794	6/1/57	USA	TX	Terrell	Two to ten miles north of Sanderson. Altitude 2800 feet.			
hispida		LL	B.H.Warnock/14886	6/1/57	USA	TX	Pecos	Hills west of Sanderson about twenty miles. Alt. 2900 feet.			
hispida		LL	B.H.Warnock/14928	6/1/57	USA	TX	Pecos	Hills west of Sanderson about twenty miles. Alt. 2900 feet.			
hispida		TEX	C.Flores/150	3/23/63	USA	TX	Zapata	"U. S. Highway 83, 5 miles southeast of San Ignacio, Texas."			

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hispida		TEX	C.B.Williams/151		USA	TX	Goliad	Goliad.			
hispida		TEX	B.L.Turner/15129	6/5/83	USA	TX	Webb	8.1 mi. S of Mirando City.			
hispida		TEX	H.Mears/1519	5/28/67	USA	TX	Pecos	"US 290, 54.6 mi. W of Ozona."			
hispida		TEX	J.A.Mears/1529	5/28/67	USA	TX	Pecos	S of the Ramada Inn in Fort Stockton.			
hispida		TEX	J.O.Parks/157	4/10/49	USA	TX	Terrell	20 miles east of Dryden.			
hispida		LL	D.S.Correll/15734	4/8/57	USA	TX	Uvalde	"On gravel bar along the Rio Frio, Garner State Park."			
hispida		LL	D.S.Correll/16001	4/18/57	USA	TX	Maverick	8 miles north of Quemado.			
hispida		LL	D.S.Correll/16544	6/1/57	USA	TX	Childress	On east edge of Childress.			
hispida		LL	D.S.Correll/16706	6/6/57	USA	TX	Comanche	On sand hills 2 miles west of Proctor.			
hispida		TEX	G.Wolcott/16T259	5/26/46	USA	TX	Frio	Sandy upland in open mesquite stand near a semi-permanent pool.			
hispida		TEX	Brackett/172	5/22/38	USA	TX	Washington				
hispida		LL	D.S.Correll/17567	7/7/57	USA	TX	Aransas	Fulton Beach area.			
hispida		LL	D.S.Correll/17818	7/10/57	USA	TX	Brooks	Several miles southeast of Falfurrias.			
hispida		TEX	G.Gamboa./180	4/16/63	USA	TX	McMullen	"State Highway 91, Fowlerton, Texas."			
hispida		TEX	A.M.Powell/1877	6/17/70	USA	TX	Ward	"6 mi. South of Pyote, near hwy. 1927."			

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hispida		LL	D.S.Correll/18911	6/2/58	USA	TX	Aransas	Among scrub oaks on inland dunes near Aransas County Airport.			
hispida		LL	R.Pena/19	3/15/64	USA	TX	Starr	"Highway 83, ten miles northwest of Roma, Texas."			
hispida		TEX	T.Head/19	8/12/47	USA	TX	JEFF DAVIS	Madera Canyon Quad. 3.5+ X 7.5+. Madera Creek and Casey Creek. Approx. five miles W. of Toyahvalle.		104.000	31.000
hispida		LL	D.S.Correll/19474	7/8/58	USA	TX	Dimmit	"Depression 16 miles northwest of Carrizo Springs, route 277."			
hispida		LL	D.S.Correll/19730	7/17/58	USA	TX	Duval	Limy hill about 6 miles northeast of Freer.			
hispida		TEX	G.G.Williges/2-S	7/11/57	USA	TX	San Patricio	"Welder Wildlife Refuge, Sect. 51."			
hispida		TEX	L.D.Smith/20		USA	TX	McLennan	North of Lake Waco.			
hispida		TEX	B.H.Warnock/20115	6/5/41	USA	TX	Brewster	Near Maravillas.			
hispida		TEX	B.H.Warnock/20125	6/10/41	USA	TX	Brewster	Near Maravillas.			
hispida		TEX	M.Butterwick/2035	3/27/76	USA	TX	Brewster	"Rio Grande, just downstream from La Linda crossing and the end of route #2627."			
hispida		TEX	R.G.Reeves/2035	6/11/43	USA	TX	Burleson	Just west of Jones Bridge.			
hispida		TEX	B.H.Warnock/20567	5/17/40	USA	TX	Llano	Enchanted Rock.			
hispida		TEX	B.H.Warnock/20712	4/26/36	USA	TX	Brewster	On top of Lizzard Mt. west of Alpine.			

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hispida		TEX	Biology Class/21	5/8/31	USA	TX	Childress	"Childress, Texas."			
hispida		TEX	B.L.Turner/21-30	3/2/01	USA	TX	Brewster	"About 5 road miles along Agua Frio dirt road from highway 118, across Terlingua Creek."		29.550	102.367
hispida		TEX	B.H.Warnock/21281	6/2/41	USA	TX	Brewster	"Pine Hill, Glass Mts."			
hispida		TEX	B.H.Warnock/21435	6/7/40	USA	TX	Brewster	"Sul Ross Campus, Alpine."			
hispida		TEX	B.H.Warnock/21574	3/20/41	USA	TX	Brewster	12 miles north of Hot Springs.			
hispida		LL	D.S.Correll/21804	5/12/59	USA	TX	El Paso	"In Franklin Mts., on trail to Cottonwood Springs, east of Canutillo."			
hispida		LL	D.S.Correll/21854	5/13/59	USA	TX	Presidio	"Silty flat along Rt. #90, anout 25 miles northwest of Marfa."			
hispida		LL	D.S.Correll/21887	5/14/59	USA	TX	Presidio	2-3 miles northwest of Redford.			
hispida		LL	D.S.Correll/21940	5/15/59	USA	TX	Jeff Davis	"14 miles south of Fort Davis, Rt. #118."			
hispida		TEX	A.Richardson/2195	6/6/74	USA	TX	Brooks	"3.5 mi. S of Falfurrias and ca. 3.0 mi. E, on Garland Lassater Ranch."			
hispida		TEX	M.E.Novoa/22	4/2/65	USA	TX	La Salle	6 miles west of Encinal on Farm Road 44.			
hispida		LL	D.S.Correll/22017	5/16/59	USA	TX	Culberson	"Delaware Springs, upper Delaware Creek."			
hispida		LL	D.S.Correll/22049	5/17/59	USA	TX	Midland	"Sandy soil, Rte. #349, 5 miles north			

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								of Midland. "			
hispida		LL	D.S.Correll/22051	5/17/59	USA	TX	Midland	"Rte. #349, 5 miles north of Midland."			
hispida		LL	D.S.Correll/22099	5/18/59	USA	TX	Kent	"2 miles east of Clairemont, Hwy. #380."			
hispida		LL	D.S.Correll/22114	5/18/59	USA	TX	Kent	"Sandy soil, Rte. #380, 4 miles southwest of Jayton. "			
hispida		LL	D.S.Correll/22397	5/26/59	USA	TX	Leon	"Sandy soil on edge of woods, 11 miles northeast of Centerville on route #7."			
hispida		TEX	B.H.Warnock/22414	7/17/67	USA	TX	Jeff Davis	At picnic area at east entrance to Davis Mountains State Park at an elevation of 5000 feet.			
hispida		TEX	A.M.Powell/2367	6/14/72	USA	TX	Ward	"Low gypsum ridges ca. 6 mi E of Grandfalls, gypsum expoSures ca 1 mi S of Hwy 329."			
hispida		TEX	J.Garcia/24	5/2/63	USA	TX	Webb	"Laredo Junior College, Laredo, Texas."			

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hispida		TEX	M.Butterwick/2443	4/20/76	USA	TX	Hudspeth	"Common perennial in moist alluvium near oxbow lake in the vicinity of Suicide Flat, ca. 5 miles northwest of Indian Hot Springs in the southern Quitman Mountains."			
hispida		TEX	J.L.Strother/247	5/15/65	USA	TX	Kinney	Ca. 30 miles SE of Brackettville.			
hispida		TEX	R.Runyon/2531	4/13/41	USA	TX	Starr	Rio Grande City.			
hispida		LL	J.Smith/26	4/20/74	USA	TX	Maverick	18.3 mi. SE of El Indio on Road 1021.			
hispida		TEX	E.R.Cameron/260	8/10/37	USA	TX	Hidalgo	"McAllen, Texas."			
hispida		TEX	M.Butterwick/2613	4/26/76	USA	TX	El Paso	"At the base of west facing slope about 0.8 km north of power line road in the southern Hueco Mountains, ca. 30 miles east of El Paso."			
hispida		TEX	R.D.Burr/264	6/8/48	USA	TX	Bexar	Deep sand on Applewhite Rd. SE of San Antonio.			
hispida		LL	D.S.Correll/27121	3/31/63	USA	TX	Val Verde	"Near mouth of Devil+s River, pumping station."			
hispida		LL	D.S.Correll/27697	6/12/63	USA	TX	Zapata	On east side of Zapata.			
hispida		TEX	K.Boylan/282	5/23/89	USA	TX	Burnet	"Roadside pullout along Park Road 4, 0.5 mi west of Inks Dam National Fish Hatchery."			

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hispida		LL	D.S.Correll/30695	2/9/65	USA	TX	Brewster	Along Terlingua Creek between Terlingua and Study Butte.			
hispida		LL	D.S.Correll/30799	4/2/65	USA	TX	Maverick	Hills about 4 miles north of Eagle Pass.			
hispida		TEX	G.L.Webster/310	6/17/49	USA	TX	Terrell	"Blackstone Ranch, mesquite flats along Independence Creek, 20 miles south of Sheffield."			
hispida		TEX	D.E.Lemke/3150	4/21/90	USA	TX	Nueces	"Vacant lot at the intersection of Surfside Boulevard and Gulden Street, Corpus Christi; approximately 300 m W of the shore of Corpus Christi Bay."			
hispida		TEX	R.Runyon/3199	5/13/37	USA	TX	Starr	Starr County.			
hispida		TEX	V.Link/32	4/22/62	USA	TX	Duval	"U. S. Hwy. 359, Realitos, Texas."			
hispida		TEX	S.W.Sikes/320	5/10/67	USA	TX	El Paso	Ca. 5 miles west of El Paso along Interstate 10.			
hispida		TEX	R.D.Worthington/3200	8/26/78	USA	TX	El Paso	"El Paso, along northbound I-10 service road 1.9 mi. N of jct. with Mesa, 3900 ft. elev."		31.867	105.421
hispida		TEX	R.J.Fleetwood/3203	3/28/60	USA	TX	Hidalgo	On or near Santa Ana National Wildlife Refuge.			
hispida		TEX	E.J.Palmer/32081	10/8/26	USA	TX	Jeff Davis	Near Ft. Davis.			
hispida		LL	L.Constance/3225	4/1/48	USA	TX	Duval	"Seven miles SE of San Diego, Duval			

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								County."			
hispida		TEX	G.Webster/32288	4/28/97	USA	TX	VAL VERDE	"Devils River State Natural Area; top of mesa between Speed Canyon and East Canyon, mosaic of thickets (junipers dominant) and grassy openings on limestone. Elev. 580-600 meters."		29.933	99.100
hispida		LL	L.Constance/3230	4/2/48	USA	TX	Brooks	4 miles south of Falfurrias.			
hispida		LL	L.Constance/3237	4/4/48	USA	TX	Starr	10 miles W of Rio Grande City.			
hispida		TEX	W.L.Bray/324	05/14/1899	USA	TX	Kimble	"Llano, Texas."			
hispida		LL	D.S.Correll/32645	4/22/66	USA	TX	Brewster	"Mouth of Tornillo Creek at Hot Springs, Big Bend National Park."			
hispida		TEX	B.C.Tharp/3369	8/28/25	USA	TX	Pecos	50 mi. from Ft. Stockton on Sheffield Road.			
hispida		TEX	M.C.Johnson/3411	5/1/54	USA	TX	Medina	2 mi. SW of Devine.			
hispida		LL	J.R.Crutchfield/3478	7/18/67	USA	TX	Childress	Buck Creek at US #83 bridge apprx. 1 mile north of junction with St. Hwy. #256.			
hispida		TEX	R.D.Worthington/3500	9/16/78	USA	TX	El Paso	"Franklin Mountains, top of South Franklin Mountain, 6700 ft. elev."			

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hispida		TEX	M.C.Johnston/3813	3/30/59	USA	TX	Webb	Along road to Carrizo Springs (US 83) 9 miles northwest of junciton with US 81.			
hispida		LL	D.S.Correll/38330	4/6/70	USA	TX	El Paso	"War Road, about 1 mi. NW of US #54, east slope of Franklin Mts."			
hispida		LL	D.S.Correll/38552	5/1/70	USA	TX	El Paso	"Bajada, east slope of Franklin Mt., north of El Paso, off War Road."			
hispida		LL	D.S.Correll/38611	5/2/70	USA	TX	El Paso	"War Road, north of El Paso."			
hispida		LL	D.S.Correll/38626	5/3/70	USA	TX	Culberson	"East of intersection of Rural Rt. 1108 and Hwy. 180, State line."			
hispida		LL	D.S.Correll/38828	6/4/70	USA	TX	Gonzales	1 mi. north of Guadalupe River; Rte. #80.			
hispida		TEX	M.H.Janszen/415	7/2/49	USA	TX	Culberson	Culberson County.			
hispida		TEX	R.D.Worthington/4183	4/29/79	USA	TX	EL PASO	"Franklin Mts., 0.9 mi WNW jct. Trans-Mountains Rd. and Gateway South, 4300 ft. elev."		31.904	105.541
hispida		TEX	B.C.Tharp/42-37	7/11/41	USA	TX	Crane				
hispida		TEX	B.C.Tharp/42-39	7/10/41	USA	TX	Crane	Crane County.			
hispida		TEX	W.L.Tolstead/42348	5/28/43	USA	TX	Taylor	Abilene State Park.			
hispida		TEX	W.L.Brav./429		USA	TX	Borden	"Uncommon by roadside 25 mi north of Gail, Texas."			
hispida		TEX	B.C.Tharprp/43-781	6/21/43	USA	TX	Pecos	Pecos County.			

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hispida		TEX	B.C.Tharp/43-782	7/8/43	USA	TX	Pecos	Pecos County.			
hispida		TEX	B.C.Tharp/43-782B	6/15/43	USA	TX	Pecos	Pecos County.			
hispida		TEX	B.L.Turner/4486	3/8/59	USA	TX	Hidalgo	6 miles east of Sullivan City.			
hispida		TEX	F.D.Heald/4489	5/15/12	USA	TX	Travis	Austin.			
hispida		TEX	B.C.Tharp/4490	7/29/29	USA	TX	Briscoe	Quitaque.			
hispida		TEX	V.L.Cory/45875	9/29/44	USA	TX	Aransas	Aransas Refuge.			
hispida		TEX	B.H.Warnock/46168	4/19/46	USA	TX	Pecos	Three miles east of Fort Stockton.			
hispida		TEX	B.C.Tharp/46237	7/24/46	USA	TX	Hudspeth	South of University Lands on the Sierra Blanca Road.			
hispida		TEX	B.H.Warnock/46285	6/13/46	USA	TX	Fayette	Infrequent along highway at Plum between Smithville and La Grange.			
hispida		LL	B.H.Warnock/47000	2/17/47	USA	TX	Presidio	Cibolo Creek one mile north of Presidio. Alt. 2600 feet.			
hispida		TEX	B.Ertter/4705	3/21/83	USA	TX	Brewster	"US 385 ca. 21 mi. S of Marathon, elev. ca. 3400+."			
hispida		TEX	B.C.Tharpharp/48375	5/26/48	USA	TX	Kenedy	"Laguna Madre, Isla Potrero Lopena."			
hispida		TEX	B.Ertter/4867	6/25/83	USA	TX	Blanco	"Pedernales Falls State Park, above river below campground, elev. ca. 800+."			
hispida		TEX	B.C.Tharp/49082		USA	TX	Kenedy	"El Toro Island, - mud flats+ of the Laguna Madre."			

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hispida		TEX	B.C.Tharp/49168	7/16/49	USA	TX	Lavaca	"Along highway 111, about 18 miles southeast of Yoakum."			
hispida		TEX	R.Bruno/50	4/8/63	USA	TX	Webb	"Casa Blanca Lake, six miles east of Laredo."			
hispida		LL	S.Sikes/501	6/10/73	USA	TX	Culberson	Ca. 1/2 miles W of Bat Cave along grassy hillside and valley; Victoira Wildlife Managment Area.			
hispida		TEX	B.L.Turner/5027	6/16/64	USA	TX	De Witt	10 miles southeast of Yoakum.			
hispida		TEX	H.Shute/51-1716	12/25/51	USA	TX	Webb	30 miles east of Laredo.			
hispida		TEX	B.C.Tharp/51-239	4/29/49	USA	TX	Kleberg	"North of Los Olmos Creek, about 2 miles south of Riviera."			
hispida		TEX	B.C.Tharp/51-270	4/30/49	USA	TX	Hidalgo	"About 5 miles west of Mission, along railroad cut."			
hispida		TEX	B.C.Tharp/51-271	4/30/49	USA	TX	Hidalgo	"About 5 miles west of Mission, along railroad cut in brush land."			
hispida		TEX	B.C.Tharp/51-954	6/2/51	USA	TX	Travis	Watkins Ranch in NW Travis County above Cow Creek on Lake Travis.			
hispida		TEX	B.H.Warnock/510	3/19/41	USA	TX	Brewster	10 miles from Study Butte on road to Santa Helena Canyon.			
hispida		TEX	B.H.Warnock/5152	4/20/47	USA	TX	Reeves	At Balmorhea Springs.			

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hispida		LL	R.Bruno/52	4/13/63	USA	TX	Webb	"Casa Blanca Lake, six miles east of Laredo."			
hispida		TEX	B.C.Tharp/52-482	6/17/52	USA	TX	La Salle	South of Cotulla on the Yegua.			
hispida		TEX	B.H.Warnock/528	3/19/41	USA	TX	Brewster	59 miles south of Alpine.			
hispida		TEX	W.D.Higdon/53-53	4/8/48	USA	TX	Frio	Northern edge of Frio County.			
hispida		TEX	M.C.Johnston/53251.1	6/10/53	USA	TX	Aransas	Goose Island State Park.			
hispida		TEX	M.C.Johnston/53251.2	6/22/53	USA	TX	Kenedy	"La Candelaria, Norias Division of King Ranch."			
hispida		TEX	B.H.Warnock/5331	5/2/47	USA	TX	Culberson	8 miles north of Van Horn; Baylor Mts. Alt. 4500 feet.			
hispida		TEX	B.Ertter/5385	5/17/84	USA	TX	Val Verde	"Eastern outskirts of Del Rio NW of Laughlin Airforce Base, dumping area E of Dallas Road N of US 90, elev. 1100+."			
hispida		LL	J.Smith/54	5/18/74	USA	TX	Starr	8 mi W of Roma on Hwy 83.			
hispida		TEX	M.C.Johnston/54137	4/7/54	USA	TX	Jim Hogg	Red sand 5 1/2 miles south of Agua Nueva.			
hispida		TEX	O.Curry/543		USA	TX	Coleman				
hispida		TEX	M.C.Johnston/54434	4/15/54	USA	TX	Kleberg	"Along Laguna Madre, at end of pavement east of Mortilla Camphouse, Laureles Division of King Ranch."			

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hispida		TEX	C.L.York/54438	6/3/54	USA	TX	Bell	W of old Tennessee Valley site near Leon River.			
hispida		TEX	M.C.Johnston/54530	4/16/54	USA	TX	Hidalgo	U. S. 281 five miles south of Brooks Co. line.			
hispida		TEX	B.Ertter/5580	3/13/85	USA	TX	La Salle	Rt 133 just W of Artesia Wells. Elev. ca 450+.			
hispida		TEX	E.Rodriguez/57	4/14/65	USA	TX	Webb	"Mines Road, eight miles northwest of Laredo."			
hispida		TEX	B.H.Warnock/5801	5/30/47	USA	TX	El Paso	19 miles east of El Paso on Carlsbad highway.			
hispida		TEX	B.Thompson/59	4/28/58	USA	TX	Live Oak	4 mi. S of George West.			
hispida		TEX	L.D.Smith/593	6/4/47	USA	TX	McLennan	RR west of Marlin Highway.			
hispida		TEX	M.H.Mayfield/594	7/20/90	USA	TX	Atascosa	Sandy soil along FM 476 1.7 mi S of Junction with FM 3175.			
hispida		TEX	Bennet School/5986	5/20/27	USA	TX	Palo Pinto	Millsap.			
hispida		TEX	R.W.Kelting/6	6/8/49	USA	TX	Gillespie	2 miles north of Doss.			
hispida		TEX	R.J.Fleetwood/6002	3/28/62	USA	TX	Hidalgo	"Santa Ana N. W. R., end of east fence."			
hispida		TEX	M.Butterwick/616	6/2/75	USA	TX	Brewster	"Ca. 1 mile north of Tres Papalotes in the Solitario, on the Big Bend Ranch."			
hispida		TEX	J.Smith/62	5/18/74	USA	TX	Zapata	1 mi. N of San Ygnacio on Hwy. 83.			

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hispida		TEX	N.C.Henderson/63-578	4/27/63	USA	TX	Callahan	"Roadside, along US #80, at the west edge of Clyde."			
hispida		TEX	N.C.Henderson/63-688	5/3/63	USA	TX	Taylor	Along Tex #600 about 4 miles north of Abilene.			
hispida		TEX	N.C.Henderson/63-777	5/8/63	USA	TX	Jones	"Along US #277, about 8 miles south of Anson."			
hispida		TEX	N.C.Henderson/63-851	5/12/63	USA	TX	Stonewall	"Roadside, along U.S. #380, about 2 miles north of Peacock."			
hispida		TEX	G.Nesom/6390	5/5/88	USA	TX	Caldwell	"FM Rd. 713, 3.8 mi. E of jct. with FM Rd. 86 (in McMahan), 4.7 mi. W jct. with FM Rd. 304 (in Delhi)."			
hispida		TEX	R.L.Crockett/6434	3/11/44	USA	TX	Webb	Laredo.			
hispida		TEX	J.C.Johnson/647	5/6/51	USA	TX	Runnels	Border of Ballinger Lake.			
hispida		TEX	S.M.Tracy/65	4/14/1902	USA	TX	Ward	Barstow.			
hispida		LL	S.Sikes/654	6/24/73	USA	TX	Presidio	"Sierra Vieja, Capote Canyon, ca. 1 m. below Capote Falls."			
hispida		TEX	J.C.Johnson/664	5/8/51	USA	TX	Runnels	"Valley Creek crossing, three miles East of Norton."			
hispida		TEX	H.Gentry/668	7/15/50	USA	TX	Culberson	"South of Van Horn, Texas on U. S. Highway 90."			
hispida		TEX	C.M>Rogers/6745	5/31/49	USA	TX	Bexar	Five miles northeast of Lytle.			

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hispida		TEX	C.M.Rogers/6757	5/31/49	USA	TX	McMullen	"Lively Ranch, about 20 miles southwest of Tilden."			
hispida		TEX	J.A.Mears/67a	6/4/66	USA	TX	Burnet	1.2 miles E on dirt road by creek 8.8 miles S of Lampasas on 183.			
hispida		TEX	O.L.Killian/6863		USA	TX	Tarrant				
hispida		TEX	C.M.Rogers/6878	7/1/49	USA	TX	Burnet	"1 mile east of the Colorado River, near Texas Highway 29."			
hispida		TEX	A.D.Wood/691	2/24/64	USA	TX	Starr	Near Rio Grande City.			
hispida		TEX	W.F.Blair/7	7/4/47	USA	TX	Dickens	"Pitchfork Ranch, 14 mies west of Guthrie."			
hispida		TEX	W.L.Tolstead/7271	5/22/43	USA	TX	Taylor	Near Abilene.			
hispida		TEX	R.Irving/74	7/9/65	USA	TX	Winkler	Roadside 1 mi. N. of southern county line Hwy. 18.			
hispida		LL	F.L.Lewton/762	6/10/09	USA	TX	Victoria	Victoria.			
hispida		TEX	R.Herrera/7687	3/10/62	USA	TX	Zapata	"U. S. Highway 83, 13 miles north of San Ygnacio."			
hispida		TEX	R.Herrera/7697	3/10/62	USA	TX	Zapata	"U. S. Highway 83, 10 miles north of San Ygnacio."			
hispida		TEX	D.Demaree/7701	5/17/30	USA	TX	Lubbock	Lubbock.			
hispida		TEX	S.Alvarez/7774	3/23/62	USA	TX	Jim Hogg	"Farm Road 649, 11 miles north of Guerra, Texas."			
hispida		TEX	J.Ramos/7845	3/17/62	USA	TX	Zapata	"US highway 83, 12 miles south of Zapata, Texas."			

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hispida		TEX	J.Ramos/7865	3/17/62	USA	TX	Starr	Below Falcon Dam.			
hispida		TEX	S.Alvarez/7920	3/23/62	USA	TX	Starr	"Farm Road 649, 1 mile north of Viboras, Texas."			
hispida		TEX	R.McVaugh/7948	4/16/47	USA	TX	Presidio	10 miles northwest of Presidio.			
hispida		TEX	R.McVaugh/7960	4/16/47	USA	TX	Presidio	"Near Rio Grande, 11 miles north of Ruidosa."			
hispida		TEX	J.Ramos/7984	4/7/62	USA	TX	Duval	"State Highway 285, fifteen miles east of Hebbronville."			
hispida		LL	P.Turner/8001	4/10/73	USA	TX	El Paso	"East slope of Franklin Mountains along transmontane highway, ca. 10 mi. N of El Paso."			
hispida		TEX	J.Ramos/8005	4/7/62	USA	TX	Duval	"State Highway 359, six miles southwest of Realitos, Texas."			
hispida		TEX	S.Alvarez/8039	4/13/62	USA	TX	Starr	"U. S. Highway 83, 9 miles north of Roma, Texas."			
hispida		TEX	J.Soto/8066	4/18/62	USA	TX	Webb	"Ranch Road 1472, 16 miles northwest of Laredo."			
hispida		LL	L.A.Charette/817	5/4/52	USA	TX	Comal	2 miles north of New Braunfels.			
hispida		TEX	B.Thompson/83	4/28/58	USA	TX	McMullen	15 mi. N of Freer.			
hispida		TEX	A.D.Wood/831	3/22/68	USA	TX	Starr	Starr County.			
hispida		TEX	R.Sanchez/8310	4/21/62	USA	TX	Jim Hogg	"Farm Road 647, Vela Pena Ranch, 20 miles south of Mirando City."			

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hispida		TEX	R.Sanchez/8348	4/21/62	USA	TX	Starr	"Farm Road 1017, 6 miles northwest of La Gloria."			
hispida		LL	J.C.Johnson/842	6/24/52	USA	TX	Karnes	"2.5 miles E of El Tejano Cafe, Karnes City. "			
hispida		TEX	R.Runyon/844	4/26/25	USA	TX	Starr	Riogrande. Altitude: 400 ft.			
hispida		TEX	L.D.Smith/848	7/4/47	USA	TX	McLennan	North of Gholson.			
hispida		TEX	A.Armer/8729	4/23/29	USA	TX	Travis	Austin. Colorado River floodplain.			
hispida		TEX	B.C.Tharp/8808	6/14/31	USA	TX	Pecos	Pecos.			
hispida		TEX	B.H.Warnock/895	6/10/37	USA	TX	Brewster	"Painted Gap, Chisos Mts."			
hispida		TEX	F.A.Barkley/8C	7/25/46	USA	TX	Burnet	"Granite Mountain, 2 miles north of Marble Falls."			
hispida		LL	C.L.Lundel/9049	5/21/40	USA	TX	Llano	Near Inks Dam.			
hispida		TEX	M.W.Bierner/91-26	5/23/91	USA	TX	Pecos	"Hwy 67, ca 7 mi S of IH-10. "			
hispida		LL	C.L.Lundell/9109	5/25/40	USA	TX	Bastrop	"On upper bank of river, Hills Prairie, Lundell Plantation."			
hispida		LL	A.Rios/92	4/10/65	USA	TX	Duval	"Farm Road 285, 10 miles west of Falfurrias."			
hispida		LL	I.G.Patterson/92	6/7/73	USA	TX	Guadalupe	"11 mi NE of Seguin, south side of hwy 90; in edge of forest."			

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hispida		TEX	B.L.Turner/93-169	7/27/93	USA	TX	Brooks	Baurite Creek where it crosses highway 282 at the Jim Wells county line marker.			
hispida		TEX	L.D.Smith/962	7/25/47	USA	TX	McLennan	Brazos north of Childress Creek.			
hispida		TEX	B.L.Turner/97-05	3/21/97	USA	TX	Crockett	3 mi E of Pecos River along US 290.			
hispida		TEX	B.L.Turner/97-21	4/18/97	USA	TX	McCulloch	10 mi WNW of Brady along highway 87.			
hispida		TEX	B.L.Turner/97-316	7/29/97	USA	TX	Kimble	"Junction, along IH 10, north side."			
hispida		TEX	B.L.Turner/98-38	4/1/98	USA	TX	El Paso	0.5 mi. west of intersection of highway 54 and transmontane highway.			
hispida		TEX	E.R.Bogusch/981	5/9/26	USA	TX	Gonzales	Gonzales County.			
hispida		TEX	B.L.Turner/99-399	5/23/99	USA	TX	Edwards	Ca. 23 miles NE of Rock Springs along highway 277 at Rest Stop overlooking the South Fork of the Llano River.		30.233	98.083
hispida		LL	C.L.Lundell/9905	4/2/41	USA	TX	Starr	West of Sullivan City.			
hispida		LL	B.H.Warnock/9955	5/11/51	USA	TX	Brewster	18 miles south of Alpine. Alt. 4450 feet.			
hispida		TEX	B.H.Warnock/C307	4/3/38	USA	TX	Brewster	"Boquillas, Texas."			
hispida		TEX	E.S.Nixon/G 26	4/23/66	USA	TX	Gillespie	About 9 miles north of Willow City near Serpentine Quarry.			

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hispida		TEX	E.S.Nixon/G30	4/23/66	USA	TX	Gillespie	About 9 miles north of Willow City near Serpentine Quarry.			
hispida		LL	J.Scudday/s.n.	5/7/59	USA	TX	Andrews	Andrews County.			
hispida		LL	E.J.Palmer/s.n.	4/12/17	USA	TX	El Paso	Ft. Bliss.			
hispida		TEX	E.Whitehouse/s.n.	10/18/31	USA	TX	El Paso	El Paso.			
hispida		TEX	E.Whitehouse/s.n.	4/20/32	USA	TX	Jeff Davis	Ft. Davis.			
hispida		TEX	L.C.Hinckley/s.n.		USA	TX	Presidio	Marfa.			
hispida		TEX	L.C.Hinckley/s.n.		USA	TX	Presidio	Presidio.			
hispida		TEX	H.H.York/s.n.	6/14/07	USA	TX	Pecos	Fort Stockton.			
hispida		TEX	H.C.Hanson/s.n.	3/17/19	USA	TX	Terrell	"Sanderson, Texas."			
hispida		LL	T.A.Williams/s.n.	5/18/1900	USA	TX	Taylor	Abilene.			
hispida		TEX	R.W.Strandtmann/s.n.	8/5/40	USA	TX	Gillespie	Gillespie County.			
hispida		TEX	W.L.Bray/s.n.	5/9/1899	USA	TX	Gillespie	"Fredericksburg, Texas."			
hispida		TEX	B.C.Tharp/s.n.	6/24/41	USA	TX	Medina	Medina County.			
hispida		TEX	B.C.Tharp/s.n.	6/24/41	USA	TX	Frio	Frio County.			
hispida		TEX	P.Hoglund/s.n.	4/6/30	USA	TX	Dimmit	Carrizo Springs.			
hispida		TEX	B.C.Tharp/s.n.	6/27/41	USA	TX	Live Oak	Live Oak County.			
hispida		TEX	P.Abrigo/s.n.	4/12/63	USA	TX	Webb	2 miles south of Laredo.			
hispida		LL	R.L.Crockett/s.n.	3/16/44	USA	TX	Webb	Rio Grande River at Laredo.			
hispida		TEX	Lehman/s.n.	4/3/53	USA	TX	Kenedy	Kenedy County.			
hispida		TEX	B.C.Tharp/s.n.	4/26/36	USA	TX	Travis	Colorado River - Deep Eddy.			
hispida		TEX	B.C.Tharp/s.n.	5/2/35	USA	TX	Travis	Austin.			
hispida		TEX	B.C.Tharp/s.n.	5/3/30	USA	TX	Travis	Austin.			
hispida		TEX	B.C.Tharpp/s.n.	6/10/39	USA	TX	Travis	Austin. Colorado River.			
hispida		TEX	M.Riedel/s.n.	7/18/41	USA	TX	De Witt	Western De Witt			

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								County.			
hispida		TEX	Hodges Oak Park School/s.n.		USA	TX	Eastland	Danger.			
hispida		TEX	L.C.Gough/s.n.	4/5/21	USA	TX	Erath				
hispida		TEX	I.Cooper/s.n.	5/30/30	USA	TX	Hood	Granburg.			
hispida		TEX	L.McConal/s.n.	4/30/30	USA	TX	Mills	"Goldthwaite, Texas."			
hispida		TEX	J.B.McBryde/s.n.		USA	TX	Caldwell				
hispida		TEX	M.Hynes/s.n.	6/2/26	USA	TX	Dallas	"Dallas, Texas."			
hispida		TEX	B.C.Tharp/s.n.	7/10/41	USA	TX	Gaines	9 mi. S. Seagraves & Seminole.			
hispida		TEX	Wild Flower Contest/s.n.		USA	TX	Fisher	"Rotan, Texas."			
hispida		TEX	Mrs. V.E.Stanfield/s.n.	4/19/31	USA	TX	Nolan	Sweetwater.			
hispida		TEX	Group/s.n.		USA	TX	Reagan	"Best, Texas."			
hispida		TEX	B.C.Tharp/s.n.	6/13/41	USA	TX	Stephens	Ivan Hill.			
hispida		TEX	B.H.Warnock/T189	8/8/36	USA	TX	Pecos	"On farms at Fort Stockton, Block I area."			
hispida		TEX	B.H.Warnock/T289	4/2/38	USA	TX	Brewster	Maravillas Crossing.			
hispida		TEX	B.H.Warnock/T290	4/2/38	USA	TX	Brewster	Near Persimmon Gap.			
hispida		GH	Berlandier/2389								
hitchcockii		TEX	T.F.Stuessy/265	1965	Mex.	NL	GALEANA	Galeana 2.5 mi al S.		24.800	-100.056
hitchcockii		TEX	C. D. R. I./1056	1984	Mex.	NL	GALEANA	Galeana cerca de Sta Rita		24.824	-100.077
hitchcockii		TEX	M.A.Carranza/1454	1991	Mex.	NL	GALEANA	proximidades al poblado de Galeana (Nuevo Leon - GALEANA)		24.717	-100.100
hitchcockii		TEX	J.Grimes/2312	1982	Mex.	NL	GALEANA	About 7 mi E of Ejido San Roberto N of Santo Domingo. In the foothills of Cerro Potos?		24.750	-100.200

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hitchcockii		TEX	J.M.Poole/2470	1981	Mex.	NL	ND	Ca 1.8 mi NW of Galeana on rd to San Lucas		24.933	-100.150
hitchcockii		TEX	M.C.Johnston/4211	1959	Mex.	NL	GALEANA	Entronque San Roberto 7 mi al E carr a Galeana.		24.695	-100.193
hitchcockii		TEX	J.Nesom/7615	1993	Mex.	NL	GALEANA	Ca 5 Km NW of Village of R?o San Jos? R?o San Jos? Canyon		24.633	-99.917
hitchcockii		TEX	B.L.Turner/15558	1985	Mex.	NL	ND	3.2 mi S of Galeana just E of rd (Nuevo Leon - ND)		24.783	-100.050
hitchcockii		TEX	G.B.Hinton/18345	1981	Mex.	NL	GALEANA	Santa Rita (Santa Rita de Cordeladas)		24.806	-100.076
hitchcockii		TEX	G.B.Hinton/18785	1984	Mex.	NL	GALEANA	Santa Rita.		24.753	-100.268
hitchcockii		TEX	G.B.Hinton/19430	1989	Mex.	NL	RAYONES	Rayones 3 Km al S.		24.995	-100.065
hitchcockii		TEX	G.B.Hinton/20950	1991	Mex.	NL	ARAMBERRI	La Ascensi?n.		24.324	-99.913
hitchcockii		TEX	G.B.Hinton/21732	1991	Mex.	NL	GALEANA	La Poza 21.375 Km al SE carr a R?o de San Jos?.		24.580	-99.965
hitchcockii		LL, TEX	D.Bogler/129	26 Aug 1987	Mex.	NL		Ed. Nuevo Leon. Intersection of road to Nva. Primera and road to Galeana coming from Hwy. 57. Open forest dominated by Yuccas. Chalky soils, perhaps gypsum. Area heavily grazed.	1220		
hitchcockii		LL, TEX	G.B.Hinton/18084	5 Nov 1983	Mex.	NL	Galeana	El Sauce	2420		
hitchcockii		TEX	B.L.Turner/6325	1970	Mex.	NL	GALEANA	Entronque San Roberto 17 mi al E.		24.719	-100.054
hitchcockii		GH	V.H.Chase/7637	29 Jul 1939	Mex.	NL	Galeana				

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hitchcockii		LL, TEX	B.L.Turner/93-157	26 Jul 1991	Mex.	NL	Galeana	5 km S of Galeana in gypseous soils in pine forest littered with garbage and trash along small stream			
hitchcockii		TEX	B.L.Turner/A-36	1979	Mex.	NL	GALEANA	Galeana 12 mi al NW.		24.899	-100.212
hitchcockii		TEX	R.S.Irving/	1965	Mex.	NL	GALEANA	Galeana 2.5 mi al S.		24.800	-100.056
hitchcockii		LL-type	D.S.Correll/	1958	Mex.	NL	ND	Galeana 3 mi al S.		24.795	-100.051
jamaicensis		GH	C.A.O'Donell/593	30 Mar 1944	Arg.	COR	Cruz del Eje	Cruz del Eje			
jamaicensis		GH	L.R.Parodi/7477	1-4 Dec 1926	Arg.	COR		Cordoba			
jamaicensis		GH	ABurkart/7484	27 Dec 1935	Arg.	COR		Sierra Chica: Estancia La Reduccion	600		
jamaicensis		GH	SLoaberla(?)/169	17 Jun 1941	Arg.	JUJ		Ledesma	500		
jamaicensis		GH	Ruiz Leal/16300	10 Sep 1954	Arg.	RIOJ	Gral. Belgrano	Olta Norara			
jamaicensis		TEX	G.Borsini/712	16 Jul 1946	Arg.	SAL	Orom				
jamaicensis		TEX	G.Borsini/712	7 Jul 1946	Arg.	SAL	Orom	Ballirriom(?) - Agua Linda			
jamaicensis		GH	Lillo/2337	8 Oct 1899	Arg.	TUC		Monteros			
jamaicensis		GH	Monetti/45212	1 Jun 1913	Arg.	TUC	Leales	Las Salinas	270		
jamaicensis		GH	J.I.Northrop/166	Jan 1890	Bah.						
jamaicensis		GH	P.Wilson/7879	26 Dec 1907	Bahamas						
jamaicensis		GH	A.E.Wight/82	2 Feb 1905	Bahamas						
jamaicensis		GH	A.H.Curtiss/89	20 Feb & 13 Apr 1903	Bahamas						

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jamaicensis		LL, TEX	C.J.Crane/322A	9 Mar 983	Belize	CORO		Cerros Maya ruins, Lowry's Bight, coastal area.			
jamaicensis		GH	Steinbach/1660	11 Oct 1915	Bol.			("Provincia" is crossed out, and "Bolivia" is written on the Provincia line". No other locality data)	700		
jamaicensis		GH	R.A.Howard/10810	7-25 Mar 1950	BWI	GREN					
jamaicensis		GH	Wilson/1028	8 Aug 1904	Cuba						
jamaicensis		GH	C.L.Pollard/316	16 Feb 1902	Cuba	SAN					
jamaicensis		GH	C.Wright/416	1856-7	Cuba						
jamaicensis		GH	B.A.Lavastre/1913	19 Mar 1965	DR	SFM					
jamaicensis		GH	M.Fuertes (?)/1867	Aug 1912	DR						
jamaicensis		GH	A.E.Ricksecker/297	26 Feb 1896	DWI	SC					
jamaicensis		GH	P.C.Standley/21144	24-27 Feb 1922	El Sal.	SM					
jamaicensis		GH	H.von Turckheim/1266	Aug 1907	Guat.	AV					
jamaicensis		GH	H.von Tuerckheim (?)/8	Feb 1887	Guat.	AV					
jamaicensis		GH	C.C.Deam/406	17 Jan 1905	Guat.	GUA					
jamaicensis		GH	P.C.Standley/24441	24 May 1922	Guat.	IZA					
jamaicensis		GH	E.Contreras/5634	17 Mar 1966	Guat.	PET					
jamaicensis		GH	anon/2926	Jun 1892	Guat.	SR					
jamaicensis		GH	??/2859	30 Aug 1896	Guat.						

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jamaicensis		GH	E.L.Ekman/9638	1 Mar 1928	Haiti	Haiti					
jamaicensis		GH	E.L.Ekman/9638	1 Mar 1928	Haiti	Haiti					
jamaicensis		GH	E.C.Leonard/11633	28 Dec 198-9 Jan 1929	Haiti						
jamaicensis		GH	E.C.Leonard/9464	3 Feb 1926	Haiti						
jamaicensis		GH	E.L.Ekman/16489	Dec 1930	Hisp.	SD					
jamaicensis		LL, TEX	G.R.Proctor/17424	23 Feb 1958	Jam.	AND		Above Cane River Falls	200		
jamaicensis		GH	G.R.Proctor/20547	31 Jan 1960	Jam.	AND					
jamaicensis		GH	N.T.Kidder/s.n.	1885	Jam.						
jamaicensis		GH	N.T.Kidder/s.n.	9 Mar 1885	Jam.						
jamaicensis		GH	N.T.Kidder/s.n.	9 Mar 1885	Jam.						
jamaicensis		TEX	E.G.Marsh/530	1936	Mex.	COA	M?ZQUIZ	Ciudad de Melchor M·zquiz (M·zquiz)		27.878	-101.514
jamaicensis		TEX	E.M.Marsh/2104	1936	Mex.	COA	M?ZQUIZ	Ciudad de Melchor M·zquiz (M·zquiz)		27.878	-101.514
jamaicensis		GH	E.G.Marsh/2104	12 Apr 1936	Mex.	COA					
jamaicensis		GH	E.G.Marsh/2241	7 May 1939	Mex.	COA					
jamaicensis		LL	G.B.Hinton/4604	1933	Mex.	MEX	TEJUPILCO	Tejupilco de Hidalgo		18.906	-100.153
jamaicensis		TEX	J.A.Machuca N./6385	1990	Mex.	JAL	JOCOTEPEC	Zapotitlßn de Hidalgo		20.327	-103.481
jamaicensis		GH	G.B.Hinton/7583	4 Apr 1935	Mex.	MICH					
jamaicensis		GH	E.Palmer/986	Feb to Oct 1880	Mex.	MONT					

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jamaicensis		TEX	C.J.Ferguson/17	1994	Mex.	NL	HIGUERAS	Cuesta Mamulique along old unused rd through pass; N facing slopes above to W of Hwy within 1 km of the Hwy		26.203	-100.107
jamaicensis		TEX	G.Nesom/7551	1993	Mex.	NL	SABINAS Hidalgo	Ciudad Sabinas Hidalgo 40 Km al S.		26.168	-100.132
jamaicensis		TEX	F.A.Barkley/14292	1944	Mex.	NL	MONTERREY	Ciudad Monterrey 12 mi al W.		25.692	-100.492
jamaicensis		GH	F.A.Barkley/14292	27 Feb 1944	Mex.	NL					
jamaicensis		GH	F.W.Pennell/16780	17 Jun 1934	Mex.	NL					
jamaicensis		LL	R.L.McGregor/16318	1961	Mex.	SLP	CIUDAD VALLES	10 mi N of Cuidad Valles.		22.120	-98.984
jamaicensis		LL	M.C.Johnston/11110-B	1973	Mex.	SLP	ND	Estaci?n Microondas Pastoriza about 22 Km S of Matehuala (San Luis Potosi - ND)		23.418	-100.647
jamaicensis		GH	E.Palmer/23	2-8 Jun 1904	Mex.	SLP					
jamaicensis		GH	H.S.Gentry/7010	14 Mar 1944	Mex.	SIN					
jamaicensis		GH	T.S.Brandegee/s.n.	19 Sep 1904	Mex.	SIN					
jamaicensis		TEX	S.W.Sikes/159	1967	Mex.	SON	SOYOPA	Soyopa 2.4 mi N		28.798	-109.633
jamaicensis		GH	H.S.Gentry/1245	29 Jan 1935	Mex.	SON					
jamaicensis		TEX	A.C.Sanders/2546	3 Apr 1982	Mex.	SON	ALAMOS	Alamos wash less than 1 mi E of Alamos along the rd to the Village of Mercedes (Sonora - ALAMOS)		27.017	-108.917

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jamaicensis		TEX	A.C.Sanders/	1993	Mex.	SON	ALAMOS	vicinity of the dam at Presa Mocuzari (=A.R. Cortines) 27 Km (airline) NW of Alamos		27.233	-109.083
jamaicensis		TEX	F.A.Barkley/14330	1944	Mex.	TAM	NUEVO LAREDO	10 mi S of Nuevo Laredo		27.354	-99.570
jamaicensis		GH	E.Palmer/2	1-31 Jan 1910	Mex.	TAM					
jamaicensis		GH	E.Palmer/255	1 Feb to 9 Apr 1907	Mex.	TAM					
jamaicensis		TEX	J.Graham/4565C	1959	Mex.	TAM	ANTIGUO MORELOS	Gruta El Abra.		22.609	-99.024
jamaicensis		TEX	J.Crutchfield/5026B	1960	Mex.	TAM	CASAS	9 mi E of Casas on the new rd to Soto la Martina		23.748	-98.603
jamaicensis		TEX	F.Ventura A./3013	1971	Mex.	VER	ND	Plan del R?o Mpio Dos R?os (Veracruz - ND)		19.390	-96.641
jamaicensis		TEX	A.C.Sanders/9579	1990	Mex.	YUC	M?RIDA	Downtown M?rida weeds in an enclosed dirt parking lot near the corner of Calle 57 and Calle 64		20.983	-89.650
jamaicensis		GH	E.Palmer/1233	9 Jan to 6 Feb 1891	Mex.			Colima			
jamaicensis		GH	P.Valdez/15	1896	Mex.						
jamaicensis		GH	G.F.Gaumer/1602		Mex.			San Anselmo			
jamaicensis		GH	G.F.Gaumer/1657		Mex.			San Anselmo			
jamaicensis		GH	H.P.Schiefer/211	26 Nov 1943	Mex.						
jamaicensis		GH	G.F.Gaumer/326	1895	Mex.						
jamaicensis		GH	?/3856	14 Feb 1903	Mex.						
jamaicensis		GH	G.B.Hinton/4604	26 Aug 1933	Mex.						

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jamaicensis		GH	G.B.Hinton/5465	13 Jan 1934	Mex.						
jamaicensis		GH	Berlandier?/	1830	Mex.			Matamoros			
jamaicensis		GH	M.Arnoldo-Broeders/3844	Dec 1969	Neth. Ant.	BON					
jamaicensis		GH	W.E.Broadway/9126	11 Jan 1933	Trin.			Trinidad			
jamaicensis		LL	D.S.Correll/41871	10 Mar 1974	USA	FL	Dade				
jamaicensis		LL	D.S.Correll/47060	16 Apr 1976	USA	FL	Dade				
jamaicensis		GH	J.K.Small/7378	20 Jan 1916	USA	FL	Dade				
jamaicensis		GH	Fg.Rugel/82	Feb 1846	USA	FL					
jamaicensis		GH	C.Brown/5175	6 Mar 1934	USA	LA					
jamaicensis		GH	A.B.Langlois/s.n.	29 Aug 1886	USA	LA					
jamaicensis		LL, TEX	W.R.Carr/25436	26 Feb 2007	USA	TX	Jim Wells	Just S of El Caro Creek on E side of S arm of Naval Auxiliary Laning Field Orange Grove, ca. 2.2 airmiles E of jct. US Rt 281 and Co. Rd. 220. Sand Diego NE Quadrangle.	65	27.879	97.952
jamaicensis		GH	Lindheimer/1011	Nov 1851	USA	TX					
jamaicensis		GH	A.Traverse/1233	5 May 1959	USA	TX	San Patricio				
jamaicensis		GH	B.F.Bush/157	14 Apr 1899	USA	TX					
jamaicensis		GH	W.M.Canby/168	16 Mar 1900	USA	TX					
jamaicensis		GH	B.H.A.Groth/19	27 Jun 1903	USA	TX	Bexar				
jamaicensis		GH	Berlandier?/2049=639	Mar 1829	USA	TX	Bexar				

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jamaicensis		GH	J.Reverchon/2137	Apr	USA	TX					
jamaicensis		GH	V.L.Cory/2458	22 Apr 1928	USA	TX	Brewster				
jamaicensis		GH	L.Constance/3224	1 Apr 1948	USA	TX	Duval				
jamaicensis		GH	D.S.Correll/32240	16 Mar 1966	USA	TX	Zapata				
jamaicensis		GH	L.Constance/3238	4 Apr 1948	USA	TX	Starr				
jamaicensis		GH	L.Constance/3239	4 Apr 1948	USA	TX	Webb				
jamaicensis		GH	F.Lindheimer/476	1846	USA	TX					
jamaicensis		GH	V.L.Cory/51470	2 Dec 1945	USA	TX	Willacy				
jamaicensis		GH	V.L.Cory/53677	7 May 1947	USA	TX	Edwards				
jamaicensis		GH	R.Runyon/6038	1 Apr 1966	USA	TX					
jamaicensis		GH	F.Lindheimer/642=213	Nov 1849	USA	TX					
jamaicensis		GH	V.L.Cory/725	30 Apr 1929	USA	TX	illeg				
jamaicensis		GH	S.M.Tracy/9216 (illeg)	10 Apr 1905	USA	TX					
jamaicensis		GH	B.C.Tharp/s.n.	30 Mar 1933	USA	TX	Travis				
jamaicensis		GH	/g.Thurber/s.n.	Apr 1853	USA	TX					
jamaicensis		GH	W.P.Taylor/42006	28 May 1943	USA		Mason				
jamaicensis		TEX	Lindheimer/1010			TX	Comal	Comanche Spring: New Braunfels.			
jamaicensis		TEX	Lindheimer/1011			TX	Comal	"Comanche Springs, New Braunfels."			
jamaicensis		LL	P.Cabrera/107	4/5/63		TX	Zapata	"U. S. Highway 83, 5 miles north of Zapata, Texas."			

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jamaicensis		TEX	A.Traverse/1084	5/24/59		TX	CAMERON	"Laguna Atascosa National Wildlife Refuge, Unit 2. Ca 1 mi. S of sign - Impoundment No. 1+ Altitude: 10 feet."			
jamaicensis		LL	R.J.Fleetwood/10905	4/25/74		TX	Galveston	"Galveston Island State Park, SE corner of yard at Headquarters entrance."			
jamaicensis		TEX	J.C.Johnson/1121	2/15/53		TX	Karnes	"Frequent in very moist, sandy loam soil. Stream bed, 0.5 miles South of Cibolo Creek crossing, Farm-to-Market Road 887, Pawelekville."			
jamaicensis		LL	J.R.Crutchfield/1135	3/16/66		TX	Hidalgo	Bentsen-Rio Grande Valley State Park.			
jamaicensis		TEX	A.Traverse/1233	5/5/59		TX	San Patricio	"Welder Wildlife Foundation, N of Sinton, ca. 350 m SW of Moody Camp. Altitude 35 feet. "			
jamaicensis		LL	C.L.Lundell/13574	4/19/47		TX	Real	"Off US higway 83, 19 miles north of Leakey, on top of plateau."			
jamaicensis		TEX	F.A.Barkley/13644	7/23/43		TX	Travis	Barton Springs Creek.			
jamaicensis		TEX	E.R.Bogusch/1390	5/9/26		TX	Gonzales				

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jamaicensis		TEX	W.R.Carr/15875	4/25/97		TX	VAL VERDE	"E side of entrance road. 0.1-0.2 mi S of entrance gate, ca. 0.7-0.8 airmiles NNE of Dolan Falls. Dolan Falls Ranch. Dolan Springs Quadrangle. Elev. 1400-1440 ft."		29.894	99.012
jamaicensis		LL	D.S.Correll/15934	4/16/57		TX	Uvalde	"Along gravel area of Rio Frio, Garner State Park."			
jamaicensis		TEX	W.R.Carr/16020	4/7/97		TX	Val Verde	"Both sides of unpaved extension of Arkansas Ave., 0.4 mi. W of Fourth St., ca. 2.7-2.8 airmiles ESE of jct. US 90 and F. M. 2523 E of Del Rio. Laughlin AFB. Del Rio SE Quadrangle. Elev. ca. 1000 ft."		29.358	99.197
jamaicensis		TEX	W.R.Carr/16048	4/8/97		TX	Val Verde	"E side of western perimeter road ca. 0.4-0.7 mi. S of NW corner of Laughlin AFB, ca. 2.5-2.6 airmiles ESE of jct. US Rt. 90 and F. M. 2523 E of Del Rio. Del Rio SE Quadrangle. Elev. ca. 1100 ft. "		29.354	99.192
jamaicensis		LL	D.S.Correll/18180	7/18/57		TX	Uvalde	Blewett.			
jamaicensis		LL	D.S.Correll/19717	7/17/58		TX	Live Oak	14 miles southwest of George West.			

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jamaicensis		LL	D.S.Correll/19718	7/17/58		TX	Live Oak	Limy ridge 14 miles southwest of George West.			
jamaicensis		LL	D.S.Correll/20762	4/4/59		TX	Webb	"On rocky open hill about 12 miles north of Laredo, route #81."			
jamaicensis		LL	D.S.Correll/20965	4/20/59		TX	Cameron	8 miles east of Brownsville on road to Boca Chica.			
jamaicensis		TEX	J.O.Parks/230	4/10/49		TX	Val Verde	"Mile Canyon, Langtry."			
jamaicensis		TEX	R.Runyon/28	12/1/25		TX	Starr	"Riogrande, Texas. Altitude: 200 ft."			
jamaicensis		LL	D.S.Correll/28989	3/13/64		TX	Cameron	"Along Arroyo Colorado, Harlingen."			
jamaicensis		TEX	R.J.Fleetwood/3003			TX	Hidalgo	Santa Ana National Wildlife Refuge south of Alamo.			
jamaicensis		LL	D.S.Correll/30759	4/1/65		TX	Kinney	"Anacacho Mts., Anacacho Ranch, - Picnic grounds+ small pond in canyon and environs."			
jamaicensis		LL	D.S.Correll/30770	4/1/65		TX	Kinney	"Anacacho Ranch, West-facing canyon on W side of Anacacho Mts."			
jamaicensis		TEX	D.E.Lemke/3129	4/21/90		TX	Nueces	"Roadside along 4100 block of Surfside Boulevard, city of Corpus Christi. "			

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jamaicensis		TEX	G.L.Webster/317	6/18/49		TX	Terrell	"Blackstone Ranch, under mesquite trees by tank in Ligan Canyon, 20 miles south of Sheffield."			
jamaicensis		LL	L.Constance/3224	4/1/48		TX	Duval	Seven miles SE of San Diego.			
jamaicensis		LL	D.S.Correll/32240	4/16/66		TX	Zapata	Brushland 14.2 miles N of San Ygnacio.			
jamaicensis		LL	D.S.Correll/32280	3/17/66		TX	Starr	Just east of Roma.			
jamaicensis		LL	L.Constance/3238	4/4/48		TX	Starr	10 miles W of Rio Grande City.			
jamaicensis		LL	L.Constance/3239	4/4/48		TX	Webb	11 miles SE of Laredo.			
jamaicensis		TEX	R.Runyon/3262	5/13/37		TX	Hidalgo	North of Edinburg. Altitude: 15 meters.			
jamaicensis		TEX	G.G.Williges/343	4/2/60		TX	San Patricio	Three miles northwest of Mathis on the Frel+s Ranch.			
jamaicensis		TEX	R.J.Fleetwood/3452	2/24/61		TX	Cameron	Laguna Atascosa National Wildlife Refuge.			
jamaicensis		TEX	M.C.Johnston/3769	3/30/59		TX	Hidalgo	12 miles west of La Joya.			
jamaicensis		TEX	M.C.Johnston/3816	3/30/59		TX	Webb	"Along road to Carrizo Springs (U. S. 83), 9 miles northwest of junction with U. S. 81."			
jamaicensis		TEX	M.C.Johnston/3830	3/31/59		TX	Dimmit	1 mile west of Carrizo Springs.			
jamaicensis		TEX	G.L.Webster/411	6/24/49		TX	Terrell	"Blackstone Ranch, 14 miles south of Sheffield."			

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jamaicensis		TEX	R.Runyon/43	4/1/26		TX	Cameron	El Jardin. Altitude: 30 feet.			
jamaicensis		TEX	R.Runyon/435	5/5/23		TX	Cameron	"El Jardin tract, vicinity of Brownsville."			
jamaicensis		TEX	H.H.Duval/457			TX	Bastrop	"Bastrop, Texas."			
jamaicensis		TEX	B.H.Warnock/46057	3/24/46		TX	TRAVIS	"Frequent on cedar-break burn-over area, ten miles west of Austin."			
jamaicensis		TEX	B.C.Tharp/46542	11/10/46		TX	Bastrop				
jamaicensis		LL	J.Smith/476	3/26/75		TX	Bandera	"In small depressions in limestone in dry riverbed of Can Creek, ca 200 ft S of the confluence of Can Creek and drainage 12."			
jamaicensis		TEX	B.Ertter/4764	4/23/83		TX	Travis	"Loop 360 (=Capital of Texas Hwy.) in NW Austin, at Balcones Fault Historical Marker N of Spicewood Springs Rd., elev. ca. 700+."			
jamaicensis		TEX	B.C.Tharp/48-78	12/5/48		TX	Starr	"Los Olmos Creek, along higway just outside Rio Grande City."			
jamaicensis		TEX	A.L.Ripple/51-599	4/8/50		TX	Fayette	Muldoon.			
jamaicensis		TEX	R.Runyon/5159	4/7/37		TX	Cameron	"Brownsville, collected at 810 E St. Charles Street."			
jamaicensis		TEX	R.Runyon/5160	5/10/24		TX	Cameron	El Jardin tract near Brownsville.			

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jamaicensis		TEX	M.C.Johnston/54151	3/9/54		TX	Cameron	Along Arroyo Colorado at Boy Scout Camp Perry.			
jamaicensis		LL	M.C.Johnston/542203	11/26/54		TX	Cameron	"On Loma de la Estrella, a clay dune on the Boca Chica highway."			
jamaicensis		TEX	M.C.Johnston/54602	4/20/54		TX	Kenedy	"Southern Saltillo Pasture, Norias Division of King Ranch."			
jamaicensis		TEX	B.Ertter/5553	2/24/85		TX	McMullen	"Rt. 16 between Freer & Tilden, 0.9 mi S of Leopard Cr., 4.2 mi S of jct 1962 (=ca 9 mi S of Nueces River). Elev. ca. 360+."			
jamaicensis		TEX	A.D.Wood/572	2/21/64		TX	Starr	Roadside park west of Sullivan City.			
jamaicensis		TEX	G.B.Wolcott/58	4/17/42		TX	Williamson	"Part of clump lawn, Georgetown."			
jamaicensis		TEX	R.Runyon/6038	4/1/66		TX	Cameron	Brownsville.			
jamaicensis		TEX	R.Runyon/6066	5/23/66		TX	Cameron	"Resaca Park Ground, Brownsville."			
jamaicensis		TEX	R.Runyon/631	3/10/24		TX	Cameron	El Jardin. Altitude: 30 feet.			
jamaicensis		TEX	A.D.Wood/686	2/27/64		TX	Starr	"10 miles northwest of Roma, Texas."			
jamaicensis		TEX	L.D.Smith/793	6/30/47		TX	McLennan	"South 7th St., Waco."			
jamaicensis		TEX	E.Whitehouse/8725	6/26/29		TX	Travis	"Hamilton Pool, W of Austin."			
jamaicensis		TEX	E.Whitehouse/8725	5/3/31		TX	Johnson	"Cleburne, Texas."			

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jamaicensis		TEX	E.Whitehouse/8726	9/7/30		TX	Hays	Wimberly.			
jamaicensis		TEX	S.M.Tracy/9216	4/10/05		TX	Kleberg	"Kingsville, Texas."			
jamaicensis		TEX	B.L.Turner/93-73X	6/30/93		TX	Kinney	6.4 mi. NE of Bracketville along state Hwy. 324.			
jamaicensis		TEX	J.C.Johnson/936	7/5/52		TX	Karnes	"San Antonio River Crossing, State Hwy. 123, Panna Maria."			
jamaicensis		TEX	B.L.Turner/97-113	5/15/97		TX	Bandera	"Ca. 2 mi. W of Bandera, where highway 270 crosses Medina River, west side."			
jamaicensis		TEX	B.L.Turner/99-84	4/7/99		TX	Kimble	"Ca. 2 miles north of IH 10 along Segovia Exit, along perennial creek just north of Johnson Draw."		30.467	98.333
jamaicensis		TEX	E.Whitehouse/s.n.	4/1/33		TX	Val Verde	"Pecos River, W of Del Rio, Texas."			
jamaicensis		TEX	Mrs. E.J.Walker/s.n.			TX	Hidalgo	"La Joya, Texas."			
jamaicensis		TEX	M.S.Young/s.n.	4/8/14		TX	Travis	Near Barton Creek.			
jamaicensis		TEX	B.C.Tharp/s.n.	4/30/36		TX	Travis	"Colorado River, Deep Eddy."			
jamaicensis		TEX	R.Runyon/s.n.	4/9/60		TX	San Patricio	"Welder Wildlife Refuge, Sinton, Texas."			
jamaicensis		TEX	B.C.Tharp/s.n.	3/3/34		TX	Willacy	Redfish Bay.			
jamaicensis		TEX	H.B.Parks/s.n.	4/7/47		TX	Brazos	"College Station, Texas."			
jamaicensis		GH	C.Wright/s.n.								
jamaicensis		GH	C.Wright/s.n.								
johnstonii		GH	C.G.Pringle/120	1885	Mex.	CHI					
johnstonii		TEX	C.G.Pringle/120	1885	Mex.	COA	ND	Jimulco		25.119	-103.359

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johnstonii		TEX	A.Rodriguez/2402	1984	Mex.	COA	PARRAS	Ejido el Capul?n aprox 10 Km al SW de Parras de la Fte.; Sa de Parras		25.383	-102.217
johnstonii		TEX	J.A.Villarreal/4420	32380	Mex.	COA	TORRE?N	Sierra de Jimulco, Mina San Jose, approx 10 km al NE de la Flor de Jimulco	2150	25.108	-103.225
johnstonii		TEX	G.B.Hinton/23340	1993	Mex.	COA	PARRAS	Parras de La Fuente (Parras) S of		25.430	-102.177
johnstonii		TEX	G.B.Hinton/27443	1999	Mex.	COA	PARRAS	Parras de La Fuente (Parras)-Tanque Menchaca		25.342	-102.193
johnstonii		US	C.G.Pringle/120	14 May 1885	Mex.	COA		Mountain walls, Jimulco			
johnstonii		NY	C.G.Pringle/120	14 May 1885	Mex.	COA		Mountain walls, Jimulco			
johnstonii		NY	C.G.Pringle/120	14 May 1885	Mex.	COA		Mountain walls, Jimulco			
johnstonii		MO	J.A.Villarreal/5523	21 Oct 1989	Mex.	COA		Sierra de Jimulco, 150 km al E. de la mina de San Jose.	2100	25.100	102.783
johnstonii		US	I.M.Johnston/7740	17 Sep 1938	Mex.	COA		Road from Parras to Torreon (via Pena and Viesca); 6 miles west of Viesca			
johnstonii		GH	I.M.Johnston/7740	17 Sep 1938	Mex.	COA		Road from Parras to Torreon (via Pena and Viesca): 6 miles west of Viesca on limestone cliffs in steep canyon			
johnstonii		GH	I.M.Johnston/8739	2 Sep 1941	Mex.	COA					
johnstonii		US	F.Shreve/8774	17 Sep 1938	Mex.	COA		6 mi. NW of Viesca	1300		

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johnstonii		NY	C.G.Pringle/s.n.	14 May 1885	Mex.	COA		Limestone ledges, Jimulco			
latifolia		GH	P.C.Standley/63250	21 Jan 1939	Guat.	SAC		Barranco above Duenas	1590		
latifolia		GH	H.E.Moore, Jr./1444	10 Oct 1947	Mex.	HID	Huichapan	Muni: Nopala. Glades in oak woods, lower slopes of Mt. Lena, west of Lena Station (FCNM)	2500		
latifolia		GH	Galeotti/1068		Mex.	OAX					
latifolia		GH	E.Seler/3627	19 Jul 1902	Mex.	PUE		Texintlan, (illeg)	1900		
linearis		F	S.Avendano Reyes/50	29 Dec 1975	Mex.	VER	Tonayan	Poblado Tonayan	1780		
marshii		TEX	I.M.Johnston/9230	1941	Mex.	COA	ND	W-ern side of Potrero de la Mula about 20 km NW of Ocampo		26.340	-101.370
marshii		GH	E.G.Marsh/1036	5 Dec 1936	Mex.	COA					
marshii		GH	R.M.Stewart/1526	10 Sep 1941	Mex.	COA					
marshii		GH	I.M.Johnston/9230	18 Sep 1941	Mex.	COA					
marshii		TEX	J.A.Mears/502-A	1966	Mex.	SLP	XILITLA	8.25 mi up old rd to Xilitla		21.421	-98.979
origanifolia		TEX	A.T.Whittemore/83-004	1983	Mex.	DUR	ND	Hwy 40 ca 16 mi W of Durango (from W edge of town; probably at lE 17 from Cd Deportivo)		23.933	-104.850
origanifolia		GH	L.A.Kenoyer/1956	11 Aug 1947	Mex.	GUA					
origanifolia		GH	L.A.Kenoyer/2060	14 Aug 1947	Mex.	GUA					

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origanifolia		TEX	C.L.Gilly/13	1943	Mex.	HID	ZIMAP?N	Conjunci?n del R?o Tula con la carretera No. 85; entre Ixmiquilpan y Zimapßn		20.576	-99.343
origanifolia		TEX	I.Diaz V./486	1989	Mex.	HID	AJACUBA	Cerro El shitia 2 Km antes de llegar al poblado Emiliano Zapata sobre la carr pavimentada rumbo a Ajacuba ejido San Nicolßs Tecomatlßn		20.150	-99.017
origanifolia		GH	H.E.Moore, Jr./1380	9 Oct 1946	Mex.	HID					
origanifolia		GH	C.A.Purpus/	Sep 1905	Mex.	HID					
origanifolia		GH	G.B.Hinton/11893	1 Jun 1938	Mex.	MICH					
origanifolia		GH	C.G.Pringle/13923	5 Feb 1907	Mex.	MICH					
origanifolia		TEX	C.G.Pringle/150091-2	1907	Mex.	MOR	CUERNAVACA	Cuernavaca barranca		18.919	-99.234
origanifolia		LL	F.Chiang C/8133	1972	Mex.	SLP	ND	2 Km S of the rd jct to Lourdes on the rd from Quer?taro to SLP		21.754	-100.688
origanifolia		GH	J.G.Schaffner/732	1876	Mex.	SLP					
origanifolia		GH	L.I.Nevling/1753	14 Jul 1971	Mex.	VER					
orizabensis		NY	H.Schlumberger/523		Mex.						
palmeri	argentea	GH	L.R.Standford/491	19 Jul 1941	Mex.	COA					
palmeri	argentea	GH	Vanegas?/1357	1827	Mex.						
palmeri		LL	J.M.Smith/768	1976	Mex.	COA	ND	Summit of Microwave Mariposa 20 mi E of the Ford Clock in Saltillo Hwy 40 (Coahuila - ND)		25.663	-100.749

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palmeri		TEX	E.G.Marsh/948	1936	Mex.	COA	ND	Santa Ana Canyon (Coahuila - ND)		26.340	-101.370
palmeri		TEX	R.M.Stewart/1473	1941	Mex.	COA	ND	W base of the Sa de los Guajes 7 Km E of Rancho Buena Vista		28.440	-102.400
palmeri		TEX	J.A.Villarreal/6406	1992	Mex.	COA	ARTEAGA	Sa de Arteaga camino Los Lirios-Laguna de Sßnchez (Coahuila - ARTEAGA)		25.317	-100.433
palmeri		TEX	J.A.Villarreal/6631	1992	Mex.	COA	SALTILLO	Estaci?n de Microondas Vega 8 Km W de Saltillo carr (40)		25.433	-101.100
palmeri		TEX	I.M.Johnston/9156	1941	Mex.	COA	OCAMPO	Ca±on de La Charretera Sierra la Madera along the rd up the open main canyon		27.166	-102.521
palmeri		LL	M.C.Johnston/11689	1973	Mex.	COA	ND	Mina El Aguirre±o N side of Sa de la Paila		26.092	-101.600
palmeri		TEX	G.B.Hinton/25352	1995	Mex.	COA	SALTILLO	S Jos? de Alamito -> Los Angeles		24.893	-100.759
palmeri		GH	E.Palmer/120	May 1898	Mex.	COA					
palmeri		GH	R.M.Stewart/1473	7 Sep 1941	Mex.	COA					
palmeri		GH	C.A.Purpus/1878	Mar 1905	Mex.	COA					
palmeri		GH	L.R.Stanford/247	10 Jul 1941	Mex.	COA					
palmeri		GH	E.Palmer/856	Sep 1880	Mex.	COA		25 mi SW of Monclova			
palmeri		GH	I.M.Johnston/9156	16 Sep 1941	Mex.	COA					
palmeri		GH	V.H.Chase/7460 1/2	15 Jul 1939	Mex.	HID	Muni. Jacala	mountainside	1370		

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palmeri		TEX	B.B.Simpson/91-7-18-11	1991	Mex.	HID	CARDONAL	San Crist?bal 1 mi NE por el camino a las grutas de Tolantongo; 10 mi despu?s de la desviaci?n a Cardonal		20.598	-98.992
palmeri		LL	R.L.McGregor/26	1963	Mex.	NL	ITURBIDE	Iturbide 7 mi al W.		24.752	-99.993
palmeri		LL	C.Wells/569	1977	Mex.	NL	GENERAL ZARAGOZA	Zaragoza 4.5 mi al SSW.		23.939	-99.791
palmeri		TEX	C.H.Mueller/1025	1934	Mex.	NL	GALEANA	Galeana 15 mi al SW.		24.686	-100.136
palmeri		TEX	J.G.Saunders/1357	9999	Mex.	NL	DOCTOR ARROYO	Capadero El (Capadero Grande)		23.704	-100.117
palmeri		TEX	G.B.Hinton/1360	1990	Mex.	NL	GALEANA	Galeana 13.345 Km al N carr a Rayones.		24.916	-100.075
palmeri		TEX	D.Flyr/1537	1970	Mex.	NL	DOCTOR ARROYO	Matehuala 18 mi E carretera 3		23.679	-100.390
palmeri		TEX	G.B.Hinton/1580	1991	Mex.	NL	ITURBIDE	Iturbide 15.39 Km al S carr a Camarones.		24.621	-99.817
palmeri		TEX	J.Grimes/2318	1982	Mex.	NL	GALEANA	5.2 mi E of Iturbide on M?x 60		24.250	-99.850
palmeri		TEX	M.A.Luckow/2662	1985	Mex.	NL	ARAMBERRI	La Ascensi?n 4.6 mi al N.		24.382	-99.910
palmeri		TEX	M.A.Lane/2892	1981	Mex.	NL	GARC?A	Torre de Microondas Mariposas.		25.663	-100.749
palmeri		TEX	C.P.Cowan/4634	1984	Mex.	NL	GALEANA	Catarino Rodriguez (El Potos?) 2.8 Km al E Hwy 57.		24.861	-100.316

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palmeri		LL	J.S.Henrickson/6564	1971	Mex.	NL	DOCTOR ARROYO	25 (rd) mi NE of Dr Arroyo 11.1 mi SW of La Escondida along Hwy 29 (Nuevo Leon - DOCTOR ARROYO)		23.950	-100.033
palmeri		LL	J.S.Henrickson/6597	1971	Mex.	NL	DOCTOR ARROYO	26.1 mi NE of Dr Arroyo 10 mi SW of La Escondida along Hwy 29 (Nuevo Leon - DOCTOR ARROYO)		23.950	-100.033
palmeri		LL	J.S.Henrickson/6600	1971	Mex.	NL	DOCTOR ARROYO	26.1 mi NE of Dr Arroyo 10 mi SW of La Escondida along Hwy 29 (Nuevo Leon - DOCTOR ARROYO)		23.950	-100.033
palmeri		LL	B.L.Turner/15593	1985	Mex.	NL	ND	14.4 mi S along rte 60 from San Roberto jct rd to Dr Arroyo		24.667	-100.083
palmeri		TEX	G.B.Hinton/17909	1980	Mex.	NL	ARAMBERRI	La Soledad (Rusia)		24.008	-100.046
palmeri		TEX	D.S.Correll/19797	1958	Mex.	NL	LINARES	Linares 23.5 mi al W carr a Galeana.		24.743	-99.861
palmeri		TEX	UTHerbarium/19809	1989	Mex.	NL	GALEANA	Dieciocho de Marzo.		24.889	-100.179
palmeri		TEX	D.S.Correll/19822	1958	Mex.	NL	ITURBIDE	Iturbide 2 mi al W.		24.737	-99.926
palmeri		TEX	D.S.Correll/19954	1958	Mex.	NL	GALEANA	Pablillo 1.5 mi al SW.		24.580	-100.007
palmeri		TEX	G.B.Hinton/20371	1990	Mex.	NL	ARAMBERRI	Aramberri.		24.099	-99.817
palmeri		TEX	G.B.Hinton/20596	1990	Mex.	NL	ARAMBERRI	Aramberri.		24.099	-99.817
palmeri		TEX	G.B.Hinton/21184	1991	Mex.	NL	ITURBIDE	Iturbide --> Agua Blanca		24.725	-99.900
palmeri		TEX	G.B.Hinton/21786	1992	Mex.	NL	RAYONES	Santa Rosa (Nuevo Leon - RAYONES)		25.079	-100.201
palmeri		TEX	G.B.Hinton/21965	1992	Mex.	NL	ARAMBERRI	San Francisco de Leos		24.317	-99.720

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palmeri		TEX	G.B.Hinton/22371	1992	Mex.	NL	GALEANA	La Poza 21.375 Km al SE carr a R?o de San Jos?.		24.580	-99.965
palmeri		TEX	G.B.Hinton/23619	1993	Mex.	NL	ARAMBERRI	La Escondida.		24.113	-99.926
palmeri		TEX	G.B.Hinton/23858	1993	Mex.	NL	ARAMBERRI	La Escondida 7.665 Km al E carr a Arramberri.		24.116	-99.860
palmeri		TEX	G.B.Hinton/24349	1994	Mex.	NL	SANTIAGO	La ci?nega de Gonzßlez		25.379	-100.233
palmeri		TEX	G.B.Hinton/24465	1994	Mex.	NL	GALEANA	Galeana 13.345 Km al N carr a Rayones.		24.916	-100.075
palmeri		TEX	G.B.Hinton/25361	1995	Mex.	NL	GALEANA	El Aguililla		24.970	-100.561
palmeri		TEX	G.B.Hinton/25507	1995	Mex.	NL	GALEANA	La Primavera (Charco El)		24.676	-100.157
palmeri		LL	M.C.Johnston/11051-E	1973	Mex.	NL	ND	14 Km by winding rd W of Tokio on the San Roberto-Galeana Hwy		24.683	-100.117
palmeri		GH	F.G.Meyer/2630	23 Jun 1948	Mex.	NL		Dulces Nombres, Nuevo Leon, and just east of border into Tamaulipas	1550	25.000	100.000
palmeri		GH	W.E.Manning/53267	12 Jul 1953	Mex.	NL		Wooded area near Tarey (East of Pablillo, which is 20 miles south of Galeana)	2200		
palmeri		GH	F.Shreve/9665	24 Aug 1940	Mex.	NL					
palmeri		TEX	B.L.Turner/A-6	1979	Mex.	NL	GALEANA	Puerto de Pastores 4.3 mi al E.		24.743	-99.979
palmeri		TEX	J.L.Panero E./	1996	Mex.	NL	GALEANA	Galeana 16.5 Km al N carr a Rayones.		24.938	-100.066
palmeri		TEX	T.F.Stuessy/286	1965	Mex.	SLP	GUADALC?ZAR	3 mi on rd to Guadalcßzar off of rte 80 on gravel rd		22.616	-100.483

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palmeri		LL	R.L.Hartman/2814	1974	Mex.	SLP	CERRITOS	rd to Cerritos 6 mi E of M?x 57		22.553	-100.490
palmeri		TEX	P.A.Fryxell/3816	1982	Mex.	SLP	GUADALC?ZAR	75 Km N of SLP on side rd to Guadalcßzar at Km 11.5		22.622	-100.442
palmeri		TEX	C.L.Lundell/5154	1934	Mex.	SLP	CHARCAS	Charcas		23.130	-101.116
palmeri		LL	R.V.Moran/6340	1957	Mex.	SLP	ND	Near Charco Blanco		22.633	-100.533
palmeri		LL	F.Chiang C/8144	1972	Mex.	SLP	ND	7.4 Km E of the SLP-Matehuala Hwy on the rd to Cerritos		22.517	-100.483
palmeri		TEX	M.Nee/24518	1982	Mex.	SLP	VILLA JU?REZ	Between Villa Jußrez and Buena Vista 16 Km (by rd) N of Para?so 50 Km (by air) NW of R?o Verde		22.267	-100.300
palmeri		GH	C.A.Purpus/5344	Jul 1911	Mex.	SLP					
palmeri		GH	E.palmer/615 1/2	Dec 1878 to Feb 1879	Mex.	SLP					
palmeri		GH	I.M.Johnston/7503	10 Sep 1938	Mex.	SLP					
palmeri		GH	J.G.Schaffner/77	Sep 1876	Mex.	SLP					
palmeri		TEX	L.E.Gieschen/SN	1982	Mex.	SLP	GUADALC?ZAR	To Guadalcßzar		22.583	-100.500
palmeri		TEX	S.Ginzbarg/127	1985	Mex.	TAM	PALMILLAS	Carr Victoria-SLP 8 mi S of Palmillas		23.188	-99.554
palmeri		TEX	C.P.Cowan/3864	1983	Mex.	TAM	TULA	Ciudad Tula 24 mi al N.		23.325	-99.678
palmeri		LL	M.C.Johnston/11172	1973	Mex.	TAM	ND	18 Km SE of Bustamante toward La Presita and Tula by winding rd (Tamaulipas - ND)		23.333	-99.667

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palmeri		GH	L.R.Stanford/776a	8 Aug 1941	Mex.	TAM					
palmeri		LL	M.C.Johnston/10459-A	1973	Mex.	ZAC	ND	2 Km SE of Coapa		24.767	-102.150
palmeri		LL	M.C.Johnston/10490-A	1973	Mex.	ZAC	ND	Puerto de Rocamontes at the Zacatecas-Coahuila state line		24.739	-101.178
palmeri		GH	C.C.Parry/15?	1878	Mex.			Saltillo			
parviflora		GH	D.D.Keck/2910	1 Jul 1934	USA	CA	Mono				
parviflora		GH	J.H.Christ/7198	14 May 1937	USA	ID	Gooding				
parviflora		TEX	J.L.Gentry, Jr./1518	14 Jun 1967	USA	NV	Humboldt				
parviflora		GH	B.Maguire/25477	15 Jun 1945	USA	NV	Nye				
parviflora		GH	L.Constance/3294	7 Jun 1949	USA	NV	Churchill				
parviflora		GH	L.Constance/3299	9 Jun 1949	USA	NV	Humboldt				
parviflora		GH	W.H.Huckley/340	1880	USA	NV					
parviflora		GH	A.Eastwood/9475	15 May 1941	USA	NV	Esmeralda				
parviflora		GH	J.W.Thompson/12165	18 Jul 1935	USA	OR	Harney				
parviflora		GH	J.B.Lieberg/2072	20 May 1896	USA	OR					
parviflora		GH	B.Maguire/26459	18 un 1946	USA	OR					
parviflora		GH	L.Constance/3302	10 Jun 1949	USA	OR	Deschutes				
parviflora		GH	T.Howell/492	16 Jun 1885	USA	OR					
parviflora		GH	L.F.Henderson/5091	4 May 1925	USA	OR	Grant				
parviflora		GH	L.F.Henderson/5360	22 Jun1925	USA	OR	Grant				
parviflora		GH	A.N.Steward/7104	21 Jun 1956	USA	OR	Deschutes				
parviflora		GH	A.Cronquist/7159	14 Jun	USA	OR	Deschutes				

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parviflora		GH	E.Nelson/828	1953 s.d.	USA	OR	Crook				
parviflora		TEX	A.Cronquist/8305	30 May 1959	USA	OR	Harney				
parviflora		GH	A.Cronquist/8305	30 May 959	USA	OR	Harney				
parviflora		GH	W.C.Cusick/1957	21 Junn 1898	USA	OR		dry soil in the Malheur region			
parviflora		TEX	N.H.Holmgren/1914	12 Jun 1965	USA	UT	Uintah				
parviflora		GH	R.C.Rollins/2018	16 Jun 1937	USA	UT	Uintah				
parviflora		GH	E.H.Graham/8886	16 May 1935	USA	UT	Uintah				
parviflora		GH	L.F.Henderson/2402	Jun 1892	USA	WA					
parviflora		GH	J.H.Sandberg/259	22 Jun 1893	USA	WA	Douglas				
parviflora		GH	C.V.Piper/2968	29 Ma 1899	USA	WA					
parviflora		GH	J.B.Lieberg/325	25 Jun 1894	USA	WA					
parviflora		GH	J.S.Brandegee/978	Jun 883	USA	WA					
parvifolia		TEX	J.L.Panero E./7379	1999	Mex.	COA	ALLENDE	Km 45.3 de la carr de cuota Allende-Sabinas		28.261	-100.939
parvifolia		LL	M.C.Johnston/10161-E	1973	Mex.	COA	ND	Sa de La Rata		27.083	-101.033
parvifolia		LL	M.C.Johnston/10280-A	1973	Mex.	COA	ND	3 Km NW of Santa Genoveva		26.350	-101.217
parvifolia		LL	F.Chiang C/7501-A	1972	Mex.	COA	ND	18 Km W of Cd Acu±a near Rancho San Lorenzo on the rd to Rancho San Miguel		29.250	-101.150
parvifolia		GH	C.G.Pringle/9173	19 Apr 1900	Mex.	COA					

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parvifolia		TEX	J.Crutchfield/6057	1960	Mex.	NL	GENERAL BRAVO	General Bravo 30 mi E carretera 40		25.909	-98.727
parvifolia		TEX	M.C.Carlson/2742	1954	Mex.	TAM	MANTE EL	Ciudad Mante 214.55 Km al NW Hwy 85.		24.342	-99.254
parvifolia		TEX	P.A.Fryxell/3693	1981	Mex.	TAM	SOTO LA MARINA	Soto la Marina 26 Km al E carr a La Pesca.		23.816	-97.975
parvifolia		TEX	J.Graham/4379	1959	Mex.	TAM	REYNOSA	48 mi from Reynosa on the San Fernando rd 27 mi from Matamoros-San Fernando Hwy turnoff		25.410	-98.221
parvifolia		TEX	M.C.Johnston/4903	1959	Mex.	TAM	JIM?NEZ	6 mi N of Santander Jim?nez		24.296	-98.451
parvifolia		TEX	C.P.Cowan/5209	1985	Mex.	TAM	CASAS	13.6 Km from Villa de Casas toward Soto La Marina		23.746	-98.611
parvifolia		TEX	L.Lowrey/13270	1988	Mex.	TAM	SOTO LA MARINA	Soto la Marina 41.025 Km al W antigua carr a Casas.		23.566	-98.467
parvifolia		GH	E.W.Nelson/6606	26-27 Feb 1902	Mex.	TAM					
parvifolia		GH	E.Palmer/2023	Feb to Oct 1880	Mex.						
parvifolia		GH	D.S.Correll/16000	18 Apr 1957	USA	TX	Maverick				
parvifolia		GH	H.B.Parks/18028	14 Mar 1936	USA	TX	Hidalgo				
parvifolia		GH	D.S.Correll/19451	8 Jul 1958	USA	TX	Val Verde				
parvifolia		GH	D.S.Correll/19700	17 Jul 1958	USA	TX	Bee				
parvifolia		GH	D.S.Correll/35460	14 Dec 1967	USA	TX	Starr				

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parvifolia		LL	C.L.Lundell/10122	4/9/41		TX	Zapata	"Off US 83, 23 miles northwest of Roma, in scrub."			
parvifolia		LL	D.S.Correll/16000	4/18/57		TX	Maverick	8 miles north of Quemado.			
parvifolia		LL	D.S.Correll/19439	7/8/58		TX	Val Verde	2 miles southeast of Del Rio.			
parvifolia		LL	D.S.Correll/19451	7/8/58		TX	VAL VERDE	"Rocky plain 7 miles southeast of Del Rio, route #277."			
parvifolia		LL	D.S.Correll/19700	7/17/58		TX	Bee	On limy slopes 10-12 miles southeast of Beeville.			
parvifolia		LL	J.Smith/24	4/20/74		TX	Maverick	18.3 mi. SE of El Indio on Road 1021.			
parvifolia		TEX	J.Mears/2498	4/16/68		TX	Val Verde	At Amistad site on campsite on Devil+s River.			
parvifolia		LL	D.S.Correll/27031	3/27/63		TX	Live Oak	On rocky brush hill about 12 miles east of George West.			
parvifolia		LL	D.S.Correll/30801	4/2/65		TX	Maverick	Hills about 4 miles north of Eagle Pass.			
parvifolia		LL	D.S.Correll/35460	12/14/67		TX	Starr	"On brush-covered rocky gravelly hills just southeast of La Porta, 5.5 miles southeas of Rio Grande City."			
parvifolia		TEX	B.C.Tharp/48-80	12/5/48		TX	Starr	"Los Olmos Creek, along highway just outside Rio Grande City."			

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parvifolia		TEX	B.Ertter/5255	12/11/83		TX	Starr	Rt. 3167 between Rio Grande City and El Sauz.			
parvifolia		TEX	A.D.Wood/570	2/21/64		TX	Starr	Hills east of Rio Grande City.			
parvifolia		LL	C.L.Lundell/9872	4/1/41		TX	Hidalgo	"East of Sullican City, in ravine on gravelly hill."			
parvifolia		GH	Berlandier?/2254=834	Nov 1830							
pringlei		US	J.N.Rose/8898	1905	Mex.	HID		Near Ixmiquilpan			
pringlei		NY	H.D.Ripley/13669	6 Nov 1964	Mex.	OAX		Barren gullied red clay hillside, near Yanhuitlan	2300		
pringlei		TEX	C.P.Cowan/5770	1985	Mex.	PUE	AJALPAN	2.8 mi (4.5 Km) W of Ajalpan on Hwy 135		18.297	-97.206
pringlei		GH	C.A.Purpus/1278	Jun 1905	Mex.	PUE		El Riego			
pringlei		NY	C.A.Purpus/1278	Jun 1905	Mex.	PUE		El Riego			
pringlei		US	J.N.Rose/5867	1 and 2 Aug 1901	Mex.	PUE		Near Tehuacan			
pringlei		US	J.N.Rose/5868	1 and 2 Aug 1901	Mex.	PUE		Near Tehuacan			
pringlei		NY	C.G.Pringle/6286	24 Dec 1895	Mex.	PUE		Hills near Tehuacan	1433		
pringlei		GH	C.G.Pringle/6286	24 Dec 1895	Mex.	PUE		Hills near Tehuacan	1680		
pringlei		US	C.G.Pringle/9515	23 Aug 1901	Mex.	PUE		Calcareous hills near Tehuacan	1867		
pringlei		GH	C.G.Pringle/9515	23 Aug 1901	Mex.	PUE		Calcareous hills near Tehuacan	1700		
pringlei		US	J.N.Rose/J.S. Rose	30 Aug to 8 Sep 1905	Mex.	PUE		Near Tehuacan			

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pringlei		NY	H.D.Ripley/13316	26 Oct 1963	Mex.	SLP		Gravelly wash in limestone hills, 5 miles west of Guadalcazar	1735		
propinqua		TEX	E.G.Marsh/142	1935	Mex.	COA	M?ZQUIZ	Ciudad de Melchor M·zquiz (M·zquiz)		27.878	-101.514
propinqua		LL	F.Chiang C/7663	1972	Mex.	COA	ND	1.5 Km NE Rancho de San Marcos on the W edge of the Sa de San Marcos (Coahuila - ND)		26.817	-102.119
propinqua		GH	E.G.Marsh, Jr./301	9 Jul 1936	Mex.	COA	Muzquiz	Muzquiz. Palm Canyon			
propinqua		GH	F.L.Wynd/333	28 Jun 1936	Mex.	COA	Muzquiz	Rancho Agua Dulce; dry arroyo on the slopes of the Sierra de San Manuel			
propinqua		LL	F.Chiang C/7550-A	1972	Mex.	COA	ND	22 Km ESE of La Cuesta del Plomo on the M·zquiz-Boquillas Hwy near the intersection of the Hwy from V. Acu±a (Coahuila - ND)		28.644	-102.305
propinqua		TEX	M.C.Carlson/2712	1954	Mex.	NL	SANTA CATARINA	Ca±?n La Huasteca.		25.535	-100.382
prostrata		TEX	J.Garcia P./932	1979	Mex.	MEX	OCUILAN	Parque Nacional Laguna de Zempoala		19.061	-99.343
prostrata		LL	G.B.Hinton/6081	1934	Mex.	MEX	TEMASCALTEPEC	San Miguel Oxtotilpan		19.148	-99.885
prostrata		TEX	R.McVaugh/10021	1949	Mex.	JAL	SAN GABRIEL	Cercanias a El Jazm?n		19.653	-103.709
prostrata		GH	R.McVaugh/10021	25 Mar 1949	Mex.	JAL					
prostrata		GH	G.B.Hinton/15097	10 Aug 1939	Mex.	MICH					
prostrata		TEX	B.Calvert/s.n.	28 Mar 1979	Mex.	MICH	ANGANGUEO	Mineral de Agangueo		19.617	-100.285

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prostrata		GH	G.B.Hinton/615	11 May 1932	Mex.			Temasclatepec, Meson Viejo			
pueblensis		GH	R.M.Stewart/2171	22 Oct 1941	Mex.	COA		10 km east of Castillon		28.250	
pueblensis		GH	R.M.Stewart/2671	20 Sep 1942	Mex.	COA		12 km southeast of Rancho Alegre (Road from Guimbalete southeast to Acatita, via Laguna del Rey)			
pueblensis		GH	E.Palmer/378	29 Aug 1904	Mex.	COA		Chojo Grande, 27 miles southeast of Saltillo			
pueblensis		GH	I.M.Johnston/7331	1-2 Sep 1938	Mex.	COA		Valley west of Melville Station (Road from Saltillo south to Concepcion del Oro)			
pueblensis		GH	C.G.Pringle/6287	24 Dec 1895	Mex.	PUE		Hills near Tehuacan	1700		
pueblensis		TEX	A.Salinas T./4914	1988	Mex.	PUE	ZAPOTITL?N	1 Km al N de Zapotitlßn de Las Salinas (frente a los viveros de cactßceas)		18.329	-97.462
pueblensis		TEX	P.Tenorio L./7368	25 Sep 1984	Mex.	PUE	ZAPOTITL?N	Cerro Quiliiltepec al W de Mesa Grande La		18.157	-97.548
pueblensis		GH	C.A.Purpus/2511	Jul 1908	Mex.	PUE		Vicinity of San Luis Tultitlanapa, Puebla, near Oaxaca			
pueblensis		NY	C.G.Pringle/6287	24 Dec 1895	Mex.	PUE		Hills near Tehuacan	1433		
pueblensis		MO	F.Chiang/F-19	23 Jul 1979	Mex.	PUE		2 km. al W de Tehuacan, Puebla.	1750		
pueblensis		US	J.N.Rose/9795	23 Aug 1905	Mex.	QUE		Near Higuerillas			

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pueblensis		GH	C.C.Parry/611	1878	Mex.	SLP		chiefly in the region of San Luis Potosi	2000	22.000	
pueblensis		GH	M.Bourgeau/610	7 Jul 1868	Mex.			Cerro de los Banos			
pusilla		GH	S.B.Parish/10192	14 May 1915	USA	CA	Inyo				
pusilla		TEX	C.B.Wolf/10578	15 May 1941	USA	CA	Inyo				
pusilla		RSA	C.B.Wolf/10578	15 May 1941	USA	CA	Inyo	Death Valley region. Valley to SE of Nopah range. 6 mi. north of Tule Springs	670		
pusilla		GH	S.B.Parish/1329	May 1882	USA	CA					
pusilla		TEX	L.Gross/1906	12 Apr 2005	USA	CA	San Bernardino				
pusilla		GH	A.M.Alexander/2725	28 Apr 1942	USA	CA	Inyo				
pusilla		GH	Lemmon/3137	1884	USA	CA		Near Calico			
pusilla		LL	L.Constance/3406	11 Apr 1952	USA	CA	San Bernardino				
pusilla		GH	S.B.Parish/9809	25 Apr 1915	USA	CA					
pusilla		RSA	D.Charlton/s.n.	5 Apr 1992	USA	CA	Inyo	Panamint Sink 20 miles north of Trona on Trona-Wildrose Rd.	800		
pusilla		RSA	M.DeDecker/1733	13 May 1967	USA	CA	Inyo	Eureka Valley: Sandy wash	1000		
pusilla		RSA	L.Gross/1906	12 Apr 2005	USA	CA	San Bernardino	Mojave Desert; Southcentral Mojave Desertregion: Marble Mountains; north of gas line road (mile 69), south of Highway 40, east of Kelbaker Road.	863	34.706	114.342

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pusilla		RSA	M.F.Gilman/2972	19 May 1938	USA	CA	Inyo	Panamint Spring, Panamint Valley	630		
pusilla		RSA	J.D.Morefield/3594 dupl. a	6 May 1986	USA	CA	Inyo	Near the SW base of Black Mountain, 1.8 mi. N4degW of Wilkerson Springs, T8S R34E S33.Coarse mixed alluvium sloping 5degWSW	1450		
pusilla		RSA	C.W.Tilforth/42549b	8 Mar 1973	USA	CA	Iyo	Death Valley National Monument: Junction of E & W side roads near mouth of Scotty's Canyon, c. 2 mi NW of Ashford Mill, in sandy outwash at foot of black lava ridge, elev. C. 0 to +100 ft.			
pusilla		RSA	R.F.Thorne/43741	31 May 1973	USA	CA	San Bernardino	E. Mojave Desert, N. slope of New York Mts: c. 1/2 mi N of Vanderbilt	1333		
pusilla		RSA	F.W.Peirson/7763	1 Apr 1928	USA	CA	San Bernardino	Open sandy expanses of Amargosa Wash, 33 miles north of Baker			
pusilla		RSA	M.E.Jones/s.n.	3 May 1904	USA	CA		Needles			

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quiexobrana		NY	A.McDonald/3014	4 Oct	Mex.	OAX	Miahuatlan	35 km ESE of Miahuatlan, 5 km NE of Santo Domingo Ozolotepec, Cerro Quiexobra. On rocky, treeless, SE slopes.	3500	16.167	95.750
quiexobrana		TEX-type	McDonald/	1990	Mex.	OAX	MIAHUATL?N DE PORFIRIO D?AZ	Santo Domingo Ozolotepec; 5 km NE		16.181	-96.277
retrorsa		CAS	A.Eastwood/6525	10 Sep 1938	USA	AZ	Coconino	Klethla Valley			
retrorsa		NY	B.Williams/s.n.	29 Aug 1909	USA	AZ					
retrorsa		NY	L.Higgins/10480	10 Aug 1977	USA	NM	Sandoval	13 mi SE of San Ysidro on Hwy 44			
retrorsa		GH	H.C.Cutler/3088	20 Sep 1939	USA	UT	San Juan				
retrorsa		NY	N.H.Holmgren/11544	18 Jun 1991	USA	UT	Garfield	Cane Spring Desert, north of Bullfrog marina, along Waterpocket Fold road, 2.7 km west of Utah Highway 276; T37S R11E S19	1175		
retrorsa		NY	L.C.Higgins/13177	23 May 1983	USA	UT	San Juan	T38S, R11E, Sec 33, Halls Crossing	1200		
retrorsa		NY	N.D.Atwood/28854	10 Aug 2002	USA	UT	San Juan	N. of Montezuma Creek	1510	37.238	108.766
retrorsa		NY	H.C.Cutler/3088	20 Sep 1939	USA	UT	San Juan	San Juan River, 12 miles above Mexican Hat	1433		
retrorsa		GH	illeg/s.n.								
rotundifolia		TEX	T.L.Wendt/1602	1976	Mex.	COA	ND	Sa de la Gloria: Ca±?n El Cono a side cyn. of C. Chilpit?n draining from N near El Chilpit?n		26.814	-101.292

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
rotundifolia		TEX	T.L.Wendt/1677	1976	Mex.	COA	CASTA?OS	Chilpit?n El Sierra La Gloria: (Ca±?n El Cono a side canyon of C. Chilipt?n draining in from N near El Chilpit?n (small rancho))		26.796	-101.330
rotundifolia		TEX	T.L.Wendt/2004	1977	Mex.	COA	ND	Just E of Cerro Providencia (lower peak NW of Picacho Carrizal); small canyon on N side of ridge between Ca±?n del Durazno (To W) and Ca±?n Avispe (to E)		26.800	-100.617
rotundifolia		LL	R.L.Hartman/3538	1973	Mex.	COA	ND	Hwy 30 11 mi W of San Buenaventura		26.340	-101.370
rotundifolia		TEX	G.Nesom/7395	1992	Mex.	COA	M?ZQUIZ	Ca 130 rd Km NW of Muzquiz on Coa Hwy 2A (Mzq.-Boquillas) then SW of 2A on tunnel rd to La Encantada mining area through the tunnel to the S side		28.483	-102.317
rotundifolia		TEX	G.Nesom/7414	1992	Mex.	COA	M?ZQUIZ	Ca 130 rd Km NW of M·zquiz on Coa Hwy 2A (Mzq-Boquillas) then SW of 2A on tunnel rd to La Encantada mining area SW side of La Encantada basin Sa Buenavista of Sa La Encantada		28.567	-102.500

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rotundifolia		TEX	I.M.Johnston/8856	1941	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 35 km W Ca±?n de Jara and canyon traversed by the railrd gorge just E of Socorro		26.931	-102.396
rotundifolia		LL	M.C.Johnston/10320	1973	Mex.	COA	ND	About 1 Km NE of Mina La Reforma at top of alluvial fan SW side of the Sa de la Purisima		26.692	-101.817
rotundifolia		TEX	J.S.Henrickson/11835	1973	Mex.	COA	ND	Ca 35 (air) mi S of Monclova in Canyon la Gavia in N side of Sa de la Gavia		26.317	-101.267
rotundifolia		TEX	J.S.Henrickson/12413	1973	Mex.	COA	TORRE?N	Torre?n Ca 24 (air) mi SW in a narrow canyon 7.1 mi W of Hwy 40 on rd to Presa Francisco Zarco along R?o Nazas		25.298	-103.689
rotundifolia		LL	M.C.Johnston/10322-B	1973	Mex.	COA	ND	About 1 Km NE of Mina La Reforma at top of alluvial fan SW side of the Sa de la Purisima		26.692	-101.817
rotundifolia		LL	M.C.Johnston/12026-A	1973	Mex.	COA	ND	Ca±?n de La Gavia above (S. of) Rancho de la Gavia		26.308	-101.250
rotundifolia		GH	I.M.Johnston/8856	4-5 Sep 1941	Mex.	COA					
rotundifolia		GH	E.Palmer/984	Feb to Oct 1880	Mex.	MONT					

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rotundifolia		TEX	M.Taylor E./428	1937	Mex.	NL	LAMPAZOS DE NARANJO	Salvador Resendez. (Nuevo Leon - LAMPAZOS DE NARANJO)		26.012	-100.386
rotundifolia		GH	E.Palmer/983	Feb to Oct 1880	Mex.			Monclova			
sandwicensis		GH	P.van Royen/10193	22 Oct 1967	USA	HI		Oahu, Bellow Airfield Beach. Low dunes behind beach.			
sandwicensis		GH	H.St. John/11519	6 Dec 1931	USA	HI		Waimanalo			
sandwicensis		GH	O.Degener/12672	28 Dec 1939	USA	HI		Nukumoi, Koloa, Kauai; T.H. along coast.			
sandwicensis		GH	F.R.Fosberg/13444	26 Dec 1936	USA	HI		Molokai. Moomoni.	10		
sandwicensis		GH	J.F.Rock/14008	20 May 1918	USA	HI		Molokai; next is hard to read: Mooruonii?			
sandwicensis		TEX	G.Webster/1497	16 Apr 1948	USA	HI		Oahu. Beach sand dunes along north shore of Mokapu Penninsula.			
sandwicensis		GH	M.J.Remy/425	1851-1855	USA	HI		Oahu			
sandwicensis		LL	W.H.Wagner, Jr./5448	2 Aug 1947	USA	HI		Oahu. Waimanalo Beach			
sandwicensis		GH	O.Degener/8426	9 Jul 1927	USA	HI		Near Wailuku, Maui, T. Hawaii			
sandwicensis		GH	ODegener/8429	16 May 1928	USA	HI		Near Karnakaipo, Molokai, T. Hawaii			
sandwicensis		GH	O.Degener/8430	24 Feb 1928	USA	HI		Waimanalo, Oahu, T. Hawaii			
sandwicensis		GH	H.Mann/97	1825	USA	HI		Oahu			
sandwicensis		TEX	H.H.Iltis/H-302	12 Jul 1967	USA	HI		Oahu, Waimanalo Beach, in inner			

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								beach			
sandwicensis			J.A.Lowell/								
sandwicensis		US	/								
schaffneri		GH	G.B.Hinton/16951	11 May 1951	Mex.	COA	Gen. Cepeda	Tulillo, District Gen. Cepeda	1200		
schaffneri		TEX	J.Valdez R./2306	1993	Mex.	NL	GALEANA	Sa Infiernillo ca±?n San Francisco. aprox 15 Km al NE de Pablillo		24.550	-99.900
schaffneri		GH	J.G.Schaffner/194	1876	Mex.	SLP					
schaffneri		US	J.G.Schaffner/395	1879	Mex.	SLP		San Luis Potosi			
schaffneri		NY	J.G.Schaffner/395	1879	Mex.	SLP					
schaffneri		NY	Schaffner/194		Mex.						
schaffneri		GH	R.Runyon/27	Dec 1925	USA	TX					
sericea		LL	C.L.Lundell/12278	1943	Mex.	DF	CUAUHT?MOC	Km 236 de la carretera No.85 Ciudad de M?xico-Nuevo Laredo; entre Zimapßn y Jacala		20.887	-99.233
sericea		LL	F.Chiang C/8086	1972	Mex.	GUA	XICH?	Xichu.		21.299	-100.056
sericea		TEX	F.W.Gould/10398	1964	Mex.	HID	JACALA DE LEDEZMA	Jacala 10 mi S por carretera federal libre No. 85		20.944	-99.211
sericea		TEX	R.W.Sanders/1078	1977	Mex.	HID	ZIMAP?N	Durango 3.4-4.5 km N por carretera federal libre No. 85		20.909	-99.214
sericea		TEX	A.Delgado S./1120	1976	Mex.	HID	ZIMAP?N	Morelos (Trancas) 4 km NE por terracer?a a Nicolßs Flores		20.807	-99.237

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sericea		TEX	A.Delgado S./1120	1976	Mex.	HID	ZIMAP?N	Morelos (Trancas) 4 km NE por terracer?a a Nicolßs Flores	1990	20.807	-99.237
sericea		GH	H.E.Moore, Jr./1743	28 Oct 1946	Mex.	HID					
sericea		GH	H.E.Moore, Jr./2132	23 Nov 1946	Mex.	HID					
sericea		TEX	M.J.Warnock/2468	1981	Mex.	HID	ZIMAP?N	Venustiano Carranza (San Pedro) 15 km NE		20.848	-99.238
sericea		TEX	J.A.Mears/268a	1966	Mex.	HID	ZIMAP?N	Entronque de la Carretera libre federal No. 85 y el camino de terracer?a al NW de Zimapßn 12 mi por el camino que sube hacia las minas.		20.813	-99.442
sericea		LL	L.Gonzßlez Q./3300	1965	Mex.	HID	ZIMAP?N	Zimapßn 20 km N por carretera federal libre No. 85		20.803	-99.260
sericea		GH	A.J.Sharp/45641	6 Jul 1945	Mex.	HID					
sericea		GH	A.J.Sharp/45641	6 Jul 1945	Mex.	HID					
sericea		GH	C.L.Hitchcock/6989	3 Jul 1940	Mex.	HID					
sericea		GH	V.F.Chase/7072	23 Jun 1939	Mex.	HID					
sericea		LL	V.H.Chase/7072	1939	Mex.	HID	JACALA DE LEDEZMA	Jacala		21.005	-99.190
sericea		TEX	M.Taylor E./727	1937	Mex.	HID	JACALA DE LEDEZMA	Jacala		21.005	-99.190
sericea		GH	V.H.Chase/7324	6 Jul 1939	Mex.	HID					
sericea		TEX	F.R.Barrie/785	1983	Mex.	HID	ZACUALTIP?N DE ANGELES	Zacualtipan 13 km S por carretera federal libre No.105		20.559	-98.627

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sericea		TEX	L.A.Prather/934	1991	Mex.	HID	ZIMAP?N	32 Km SW of Jacala along rte 85 en rte of Zimapßn (Hidalgo - ZIMAPAN)		20.917	-99.250
sericea		GH	L.A.Kenoyer/C327A	19 Aug 1940	Mex.	HID					
sericea		LL, TEX	M.T.Edwards/867	16 Aug 1937	Mex.	HID		San Vicente			
sericea		TEX	G.B.Hinton/20525	1 Sep 1990	Mex.	NL	ARAMBERRI	Aramberri.	970	24.099	-99.817
sericea		TEX	G.B.Hinton/21764	6 Nov 1991	Mex.	NL	ARAMBERRI	Puerto Los Borregos arroyo.	1300	24.265	-99.797
sericea		LL, TEX	G.B.Hinton/22559	16 Oct 1992	Mex.	NL	Zaragoza	Cerro El Viejo	1795		
sericea		LL, TEX	G.B.Hinton/22898	28 Jul 1993	Mex.	NL	Zaragoza	Cerro El Viejo	1545		
sericea		LL, TEX	G.B.Hinton/22939	17 Jun 1993	Mex.	NL	Zaragoza	Cerro El Viejo	1875		
sericea		TEX	G.B.Hinton/23102	23 Jul 1993	Mex.	NL	ARAMBERRI	La Escondida 22.36 Km al NE carr a San Francisco de Leos.	1575	24.163	-99.765
sericea		LL, TEX	G.B.Hinton/23492	23 Sep 1993	Mex.	NL	Zaragoza	Cerro Viejo	1955		
sericea		GH	U.T.Waterfall/14135	20 Aug 1957	Mex.	QUE					
sericea		GH	U.T.Waterfall/14135 (dup)	20 Aug 1957	Mex.	QUE					
sericea		TEX	R.Fernßndez N./2500	1984	Mex.	QUE	PINAL DE AMOLES	6 Km al NW de San Pedro Viejo camino a Jalpan	1650	21.117	-99.539
sericea		LL, TEX	J.L.Panero/3712	12 Oct 1993	Mex.	QUE		25 km al E de Landa de Matamoros sobre la carretera a Xilitla, ca. 14 km al E de la desviacion a Tinocol y carretera 215 a San Juan del Rio	1560		

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sericea		LL, TEX	J.Crutchfield/6134	13 Dec 1960	Mex.	QUE		12 miles east of Landa on the winding mountain road toward Xilitla, S.L.P.			
sericea		LL	J.Crutchfield/6134	1960	Mex.	QUE	LANDA DE MATAMOROS	Landa 12 mi E on the winding rd to SW towards Santa Teresa		21.286	-99.219
sericea		LL, TEX	J.M.Smith/843	12 Nov 1976	Mex.	QUE		7.3 mi SW of the San Luis Potosi-Queretaro state line.			
sericea		LL, TEX	J.M.Smith/843	12 Nov 1976	Mex.	QUE		7.3 mi SW of the San Luis Potosi-Queretaro state line.			
sericea		GH	C.G.Pringle/3059	12 Jul 1890	Mex.	SLP					
sericea		GH	C.A.Purpus/4860	Nov 1910	Mex.	SLP					
sericea		TEX	G.B.Hinton/25043	9 Nov 1994	Mex.	TAM	Hidalgo	Miradores (Tamaulipas - Hidalgo)	894	24.047	-99.314
sericea		TEX	J.Crutchfield/5607	17 Sep 1960	Mex.	TAM	VICTORIA	Ciudad Victoria 23 mi al SW Hwy 101.		23.613	-99.301
sericea		LL, TEX	J.Crutchfield/5607	17 Sep 1960	Mex.	TAM		23 miles southwest of Victoria and 19 miles northwest of Jaumave on the road between them.			
sericea		TEX	G.Nesom/5950	15 Jun 1987	Mex.	TAM	VICTORIA	7.6 mi S of Victoria on Hwy 101 4.6 mi SW of Altas Cumbres on S side of crest of Hwy	1380	23.617	-99.260
sericea		GH	Coulter/914		Mex.						
sericea		GH	Coulter/915		Mex.						

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serpylloides	serpylloides	NY	J.Henrickson/16057	12 May 1977	Mex.	COA		ca. 27 (rd) mi N of Monclova along Hwy 57, N of Primero de Mayo, in low drainage area along Hwy	380	27.267	100.783
serpylloides	serpylloides	GH	E.G.Marsh/1686	5 May 1939	Mex.	COA					
serpylloides	serpylloides	NY	E.Palmer/982	1880	Mex.	COA		Monclova			
serpylloides	serpylloides	LL	R.L.Hartman/	1973	Mex.	COA	ND	Hwy 57 2 mi S of Hermanas		26.340	-101.370
serpylloides	serpylloides	TEX	E.G.Marsh/	1939	Mex.	COA	ND	Hermanas		28.580	-101.604
serpylloides	serpylloides	TEX	E.M.Marsh/	1939	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas)		26.986	-102.067
serpylloides	serpylloides	TEX	L.E.Gieschen/	1982	Mex.	NL	ND	1.5 mi N of Pablillo on Hwy 51		24.583	-100.000
serpylloides	velutina	NY	H.D.Ripley/14510	2 Nov 1966	Mex.	COA		Rio Salado 26 miles n. of Monclova	580		
serpylloides	velutina	GH	E.G.Marsh/1572	20 Apr 1939	Mex.	COA					
serpylloides	velutina	GH	E.G.Marsh/1577	20 Apr 1939	Mex.	COA					
serpylloides	velutina	GH	E.G.Marsh/2016	23 Aug 1939	Mex.	COA					
serpylloides	velutina	GH	I.M.Johnston/7063	22-24 Aug 1938	Mex.	COA		Road from Piedras Negras south to Monclova. One mile south of Hermanas, dry heavy alkaline soil on terrace near salt marsh			
serpylloides	velutina	GH	I.M.Johnston/8868	5 Sep 1941	Mex.	COA					
serpylloides	velutina	TEX	E.G.Marsh/	1939	Mex.	COA	MONCLOVA	Monclova		26.901	-101.418

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serpylloides	velutina	TEX	A.M.Powell/	1972	Mex.	COA	ESCOBEDO	Estaci?n Hermanas 1 mi S of		27.206	-101.232
serpylloides	velutina	TEX	A.M.Powell/	1972	Mex.	COA	ESCOBEDO	Estaci?n Hermanas 1 mi S of		27.206	-101.232
serpylloides	velutina	TEX	B.L.Turner/	1971	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 20 mi E of		27.005	-101.763
serpylloides	velutina	LL	R.L.Hartman/	1973	Mex.	COA	ND	Hwy 57 2 mi S of Hermanas		26.340	-101.370
serpylloides	velutina	TEX	R.L.Hartman/	1973	Mex.	COA	ND	Hwy 57 2 mi S of Hermanas		26.340	-101.370
serpylloides	velutina	LL	D.S.Correll/	1959	Mex.	COA	ND	just S of Hermanas		26.340	-101.370
serpylloides	velutina	TEX	B.L.Turner/	1971	Mex.	COA	ESCOBEDO	Estaci?n Hermanas 0.5 mi S of along M?x Hwy 57		27.213	-101.228
serpylloides	velutina	TEX	B.L.Turner/	1970	Mex.	COA	ND	0.7 mi S of Hermanas along roadside		26.340	-101.370
serpylloides	velutina	TEX	W.R.Leverich/	1971	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 8 Km SW of		26.938	-102.120
serpylloides	velutina	LL	F.Chiang C/	1972	Mex.	COA	ND	19 Km SW of Cuatro Ci?negas (Coahuila - ND)		26.867	-102.150
serpylloides	velutina	TEX	A.M.Powell/	1972	Mex.	COA	SABINAS	Sabinas 46 mi S of Estaci?n Hermanas		27.376	-101.216
serpylloides	velutina	LL	D.S.Correll/	1959	Mex.	COA	ND	just S of Hermanas		26.340	-101.370
serpylloides	velutina	TEX	E.G.Marsh/	1939	Mex.	COA	ND	Hermanas		28.580	-101.604

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serpylloides	velutina	LL	M.C.Johnston/	1973	Mex.	COA	ND	About 2 Km SE of Estaci?n Hermanas		27.200	-101.233
serpylloides	velutina	TEX	M.Nee/	1982	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 11 Km SW of along Hwy M?x 30 2.5 Km S of turnoff to Balnearios El Mezquite		26.917	-102.139
serpylloides	velutina	TEX	M.C.Johnston/	1955	Mex.	COA	CUATROCI?NEGAS	San Juan de Boquillas (San Juan) 2.6 mi E of on the rd from Cuatroci?negas de Carranza (Cuatroci?negas) to Monclova		27.013	-101.854
serpylloides	velutina	LL	M.C.Johnston/	1973	Mex.	NL	ND	14 Km N of Rancho Las Estacas on rd to Rancho Lechuguillal		26.475	-100.833
serpylloides		NY	D.S.Correll/21294	1 May 1959	Mex.	COA		just south of Hermanas			
serpylloides		NY	R.C.Rollins/58101	17 Nov 1958	Mex.	NL		5 miles west of Santa Catarina, Monterrey to Saltillo.	1000		
serpylloides		GH	E.Palmer/982	Feb to Oct 1880	Mex.			Monclova			
shaffneri		NY	Parry/609	1878	Mex.	SLP					
spathulata		GH	C.H.Mueller/1025	15 Jul 1934	Mex.	NL					
spathulata		TEX	P.Tenorio L./7457	1984	Mex.	PUE	ND	1 Km al S de Nopala. Mpio Teotepec		18.450	-97.600

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spathulata		GH	C.A.Purpus/2584	Jul 1907	Mex.	PUE		in the vicinity of San Luis Tultitlanapa, Puebla, near Oaxaca. Cerro de Paxtle			
stenocarpa		LL	A.M.Carter/2609	1949	Mex.	BCS	ND	La Laguna hills E of La Paz		24.200	-110.267
stenocarpa		TEX	L.Constance/3144	1947	Mex.	BCS	COMOND?	La Purisima 4 mi sobre arroyo de la Purisima		26.185	-112.075
stenocarpa		GH	A.Carter/2609	31 Mar 1949	Mex.	BCS					
stenocarpa		GH	H.S.Gentry/7032	28 Apr 1944	Mex.	SIN					
stenocarpa		GH	Berlandier?/2111=694	Jun 1830	Mex.	TAM					
stenocarpa		GH	anon/1072?	Apr 1836	Mex.			Matamoros			
stenocarpa		GH	Berlandier/2525 (=1095)	April 1834	Mex.			De Matamoros al Arroyo Colorado			
stenocarpa		GH	Berlandier?/2525 ex.4	Apr 1834	Mex.			Matamoros			
stenocarpa		GH	J.Gregg/582	28 Dec 1848	Mex.						
stenocarpa		GH	Berlandier?/709	March 1830	Mex.			Matamoros			
stenocarpa		GH	E.Palmer/857	Feb to Oct 1880	Mex.						
stenocarpa		GH	Berlandier?/898	May 1831	Mex.			Matamoros			
stenocarpa		GH	anon/	Apr 1836	Mex.			Matamoros			
stenocarpa		GH	J.G.Lemmon/83	188?	USA	AZ	Yuma				
stenocarpa		GH	G.R.Vasey/illeg	1881	USA	AZ	Yuma				
stenocarpa		GH	J.G.Lemmon/165	1880	USA	CA					
stenocarpa		TEX	A.C.Sanders/23120	26 Sep 1999	UsA	CA	Riverside				
stenocarpa		GH	LeRoyAbrams/2572	19 Jun	USA	CA	Los Angeles				

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stenocarpa		GH	F.F.Gander/6940	1902 28 Jan 1939	USA	CA	San Diego				
stenocarpa			H.E.Hasse/s.n.	Oct 1889	USA	CA					
stenocarpa		GH	Berlandier?/1435=175 ex.5	Feb 1828	USA	TX		entre Laredo et Bejar			
stenocarpa		GH	D.S.Correll/32295	17 Mar 1966	USA	TX	Starr				
stenocarpa		GH	L.Constance/3235G	3 Apr 1948	USA	TX	Cameron				
stenocarpa		GH	Mrs. E.J.Walker/57	Mar	USA	TX					
stenocarpa		TEX	R.J.Fleetwood/10976	5/28/74		TX	Hidalgo	Bentsen-Rio Grande State Park. Along water of Oxbow lake.			
stenocarpa		TEX	C.B.Williams/138			TX	Goliad	Goliad. Lakeside.			
stenocarpa		LL	C.L.Lundell/14843	4/3/48		TX	Cameron	Palm Grove.			
stenocarpa		TEX	L.Hernandex/2315	4/7/89		TX	San Patricio	10 km al W de Mathis. A orillas de Lake Corpus Christi.			
stenocarpa		TEX	R.Runyon/2532	3/30/41		TX	Cameron	Brownsville.			
stenocarpa		TEX	A.Richardson/2732	2/16/80		TX	Cameron	Brownsville between river and golf course near TSC campus.			
stenocarpa		TEX	R.Runyon/3200	7/17/33		TX	Cameron	Known only from the vicinity of Brownsville.			
stenocarpa		LL	D.S.Correll/32295	3/17/66		TX	Starr	"El Sauz, along Arroyo Los Olmos."			
stenocarpa		LL	L.Constance/3235	4/3/48		TX	Cameron	"Palm Grove, 8 miles southeast of Brownsville."			
stenocarpa		TEX	R.Runyon/34	3/21/26		TX	Cameron	El Jardin. Altitude: 30 feet.			
stenocarpa		TEX	R.Runyon/5158	4/11/39		TX	Cameron	Near Brownsville.			

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stenocarpa		TEX	B.Ertter/5526	2/23/85		TX	CAMERON	"Arroyo Colorado W of Public Boat Ramp, W of Arroyo City at jct of 2925 & 1847."			
stenocarpa		TEX	Mrs. E.J.Walker/s.n.			TX	Hidalgo	La Joya.			
stenocarpa		TEX	Mrs. A.M.Davis/s.n.			TX	Cameron	Cameron County.			
stenocarpa		TEX	Lehman/s.n.	4/3/53		TX	Kleberg	Santa Gertrudis Ranch.			
stenocarpa		GH	G.E.Palmer/111	1866							
stenocarpa		GH	Berlandier?/2111=694 (dup)								
stenophylla	egena	GH	Havard/15	1882	USA	TX		Bluffs of Delaware Creek (east of Guadalupe Mts)			
stenophylla		TEX	G.Nesom/5257	1986	Mex.	CHI	AHUMADA	22.5 mi S of El Sueco on Hwy 45		29.592	-106.353
stenophylla		LL	M.C.Johnston/9048	1972	Mex.	CHI	ND	9 Km NE of Carrillo toward Guimbalete N of railrd		26.944	-103.883
stenophylla		LL, TEX	J.Henrickson/5902	24 Aug 1971	Mex.	CHI		15 miles S of Cd. Carmargo (sic) along Mex. Hwy 45 on rocky flats of Chihuahuan Desert; with Larrea, Acacia, Flourensia, Parthenium, Prosopis, Krameria, Opuntia, etc.	1300	27.517	104.983
stenophylla		GH	K.Bryan/s.n.	6 Sep 1941	Mex.	CHI					
stenophylla		LL	T.L.Wendt/655	1974	Mex.	COA	ND	Cuatro Ci?negas Basin: alkali/gypsum flats between dunes and CC-Torre?n Hwy		26.867	-102.150

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stenophylla		TEX	J.D.Bacon/1153	1971	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 76.3 mi W of on dirt rd along railrd track to Esmeralda		27.136	-103.185
stenophylla		TEX	J.D.Bacon/1218	1971	Mex.	COA	ND	0.5 mi E of Salinas on rd crossing the lake bed leading to La Chemica		26.340	-101.370
stenophylla		TEX	L.A.Prather/1500	1993	Mex.	COA	ND	About 1 Km E of the Hwy at Rancho Santa Luc?a on Hwy 30 between Monclova and Candela where the rd turns SE 2.3 mi NW of the turnoff to La Carrosa (to the S) 23.0 mi W of the intersection with Hwy 1 (Coahuila - ND)		26.833	-100.783
stenophylla		TEX	A.Richardson/1650	1971	Mex.	COA	ND	12-4 mi S of Cuatro Cienegas 2 mi W		26.340	-101.370
stenophylla		LL	C.H.Mueller/3031	1939	Mex.	COA	ND	10 mi S of San Lßzaro		26.140	-101.340
stenophylla		TEX	B.L.Turner/6185	1970	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 3 mi SW of close to railrd		26.959	-102.098
stenophylla		LL	F.Chiang C/7609	1972	Mex.	COA	ND	3 Km SW of Cuatro Ci?negas (Coahuila - ND)		26.967	-102.083

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stenophylla		LL	I.M.Johnston/8860	1941	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) W of near Divisadero		26.986	-102.067
stenophylla		TEX	I.M.Johnston/8866	1941	Mex.	COA	CUATROCI?NEGAS	El Anteojo 1 mi W of (W of Cuatroci?negas de Carranza (Cuatroci?negas)		26.990	-102.182
stenophylla		LL	F.Chiang C/9160	1972	Mex.	COA	ND	16 Km SW of Cuatro Ci?negas W of the Torre?n Hwy		26.867	-102.150
stenophylla		LL	D.S.Correll/21413	1959	Mex.	COA	MATAMOROS	Matamoro 5 mi N of Sierra Solis (about)		25.590	-103.201
stenophylla		TEX	H.S.Gentry/23140	1972	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 33 mi SSW of on Rd to San Pedro		26.646	-102.406
stenophylla		TEX	M.Nee/25357	1982	Mex.	COA	SAN PEDRO	Along Hwy M?x 30 108 Km by rd NE of San Pedro de Las Colonias		26.535	-102.479
stenophylla		TEX	T.F.Patterson/248599	1993	Mex.	COA	ND	Cerro de la Carroza W of Candela on Hwy 30 to Monclova just E of rd-side shrine at Rancho Sta Lucia		26.833	-100.750
stenophylla		TEX	J.A.Villarreal/248600	1985	Mex.	COA	CUATROCI?NEGAS	Dunas cercanas a la Poza de la Becerra en Cuatroci?negas (Coahuila - CUATROCIENEGAS)		26.883	-102.117

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stenophylla		TEX	G.Nesom/248601	1985	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) city dump area ca 2 Km W of town along RR		26.983	-102.087
stenophylla		TEX	D.Bogle/248602	1987	Mex.	COA	ND	Bolson de Cuatro Ci?negas; W of Pozo Becerra (Coahuila - ND)		26.817	-102.033
stenophylla		LL, TEX	J.M.Porter/11275	13 Sep 1996	Mex.	COA		Gypsum outcrop, ca. 20 km NNE of Torreon, on the road to Laguna del Rey from just E of Finisterre. 51.8 mi. from jct. C-41 (road to Laguna del Rey) and rd. E of Finisterre, and 56.1 mi. N of fork in rd. near Finisterre. . .	1100	26.653	102.833
stenophylla		LL, TEX	J.Henrickson/12531	18 Aug 1973	Mex.	COA		North facing slope ca 62 (air) miles SW of Cuatro Cienegas, 10 (rd) miles NE of turnoff to Las Delicias on San Pedro-Cuatro Cienegas Hwy; common along highway	850	26.317	101.350
stenophylla		GH	S.S.White/2003	24 Jul 1939	Mex.	COA					
stenophylla		GH	R.M.Stewart/2650	17 Sep 1942	Mex.	COA					
stenophylla		GH	R.M.Stewart/2722	23 Sep 1942	Mex.	COA					

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stenophylla		GH	R.M.Stewart/2834	3 Oct 1942	Mex.	COA					
stenophylla		GH	I.M.Johnston/7141	25 Aug 1938	Mex.	COA					
stenophylla		NY	T.F.Patterson/7438	18 Oct 1993	Mex.	COA		Cerro de la Carroza, west of Candela on Highway 30 to Monclova, gypsum slope below massive limestone ridge, just east of roadside shrine at Rancho Sta. Lucia, in Agave, Yucca, Opuntia grassland	550	26.833	99.250
stenophylla		GH	I.M.Johnston/7812	20 Sep 1938	Mex.	COA					
stenophylla		LL, TEX	J.Henrickson/7864	21 Sep 1971	Mex.	COA		64 (rd) miles W of Chuatro Cienegas, (6 miles W of La Vibora) on small gypsum knoll near railroad, in Bolson de Mapimi region of Chihuahuan Desert;	1250	27.150	102.950
stenophylla		GH	I.M.Johnston/8307	21 Aug 1941	Mex.	COA					
stenophylla		NY	E.Palmer/861	1 to 10 May 1880	Mex.	COA		San Lorenzo and vicinity, 22 to 27 leagues southwest from Parras			
stenophylla		GH	E.Palmer/861	Feb to Oct 1880	Mex.	COA		cited as from San Lorenzo de Laguna			
stenophylla		GH	I.M.Johnston/8866	5 Sep 1941	Mex.	COA					
stenophylla		GH	I.M.Johnston/9341	22 Sep 1941	Mex.	COA					

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stenophylla		LL, TEX	I.M.Johnston/9341	22 Sep 1941	Mex.	COA					
stenophylla		LL, TEX	J.Henrickson/7976	23 Sep 1972	Mex.	DUR		66 miles N of N. Gomez Palacio along Hwy 49, 1.3 miles S of Est. Yermo in open Chihuahuan Desert	1160	26.383	102.017
stenophylla		TEX	B.L.Turner/248603	1970	Mex.	NL	Hidalgo	5 mi SW of Hidalgo at Parque de Portrero (ca 15 airline mi NW of Monterrey)		25.934	-100.387
stenophylla		TEX	A.M.Powell/248604	1972	Mex.	NL	MONTERREY	Ciudad Monterrey 25 Km al NW.		25.872	-100.334
stenophylla		TEX	L.A.Prather/248605	1993	Mex.	NL	ND	7 mi NE of Las Estacas (about midway between Monclova and Minas on Hwy 53) on private ranch rd towards Lechuguilla		26.417	-100.800
stenophylla		TEX	B.L.Turner/248606	1993	Mex.	NL	GALEANA	Galeana 5 Km al S.		24.792	-100.049
stenophylla		TEX	W.RLeverich/248607	1971	Mex.	NL	Hidalgo	El Potrero Chico.		25.929	-100.473
stenophylla		LL, TEX	G.B.Hinton/28402	4 Sep 2005	Mex.	NL	Mina	lat 26.04172 N, long 100.44281 W; North of Los Molina	986		
stenophylla		NY	J.G.Schaffner/396	1879	Mex.	SLP					
stenophylla		US	E.Palmer/s.n.	1880	Mex.						
stevensii	gypsicola	TEX	J.S.Henrickson/	1974	Mex.	COA	ND	15.2 (rd) mi N of; Villa Ocampo along new hand-made rd to Guaje		27.550	-102.450

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stevensii	gypsicola	TEX	T.L.Wendt/	1974	Mex.	COA	ND	1.1 mi SE of Encarnaci?n de Guzmßn along rd to La Colonia de San Sebastißn in prairiedog town in the Potrero de San Isidro		24.817	-101.042
stevensii	gypsicola	TEX	A.M.Powell/	1972	Mex.	COA	MONCLOVA	Intersecci?n Hwy 53 y Hwy 57 30 mi al S.		26.436	-101.002
stevensii	gypsicola	TEX	J.S.Henrickson/	2001	Mex.	NL	GALEANA	Ca 35 air mi SE of Saltillo 0.5 mi N of Navidad or 4.2 mi N of San Rafael along Hwy 57		25.078	-100.604
stevensii	gypsicola	LL	F.Chiang C/	1972	Mex.	NL	ND	13 Km N of San Roberto jct on Hwy to Saltillo at the turnoff to Rancho La Luz		24.783	-100.333
stevensii	gypsicola	TEX	B.L.Turner/	1971	Mex.	NL	MONTERREY	Ciudad Monterrey 105 Km al NW camino a Monclova.		26.347	-100.852
stevensii	gypsicola	TEX	B.L.Turner/	1970	Mex.	NL	GALEANA	Entronque San Roberto 15 mi al S Hwy 57.		24.479	-100.313
stevensii	gypsicola	TEX	J.D.Bacon/	1971	Mex.	NL	GALEANA	San Roberto 2.8 mi al N Hwy 57.		24.751	-100.308
stevensii	gypsicola	TEX	G.B.Hinton/	1993	Mex.	NL	ARAMBERRI	La Escondida 7.665 Km al E carr a Arramberri.		24.116	-99.860
stevensii	gypsicola	TEX	G.B.Hinton/	1981	Mex.	NL	GALEANA	Santa Rita (Santa Rita de Cordeladas)		24.806	-100.076
stevensii	gypsicola	TEX	G.B.Hinton/	1981	Mex.	NL	GALEANA	Santa Rita (Santa Rita de Cordeladas)		24.806	-100.076
stevensii	gypsicola	TEX	G.B.Hinton/	1980	Mex.	NL	GALEANA	El Aguililla		24.970	-100.561

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stevensii	gypsicola	TEX	G.B.Hinton/	1989	Mex.	NL	GALEANA	El Aguililla		24.970	-100.561
stevensii	gypsicola	TEX	G.B.Hinton/	1996	Mex.	ZAC	MAZAPIL	La Colonia Cedros; (Pico Teira)		24.671	-101.771
stevensii	stevensii	GH	R.L.McGregor/14471	24 Jun 1959	USA	KA	Barber				
stevensii	stevensii	GH	J.E.Bare/2418	2 Jul 1970	USA	KA	Barber				
stevensii	stevensii	TEX	J.B.Secor/35	29 Jul 1967	USA	NM					
stevensii	stevensii	TEX	U.T.Waterfall/11975	4 Jun 1954	USA	OK	Jackson				
stevensii	stevensii	GH	U.T.Waterfall/11975	4 Jun 1954	USA	OK	Jackson				
stevensii	stevensii	GH	U.T.Waterfall/13132	29 May 1957	USA	OK	Greer				
stevensii	stevensii	LL	U.T.Waterfall/17281	2 Jul 1967	USA	OK	Custer				
stevensii	stevensii	GH	U.T.Waterfall/2004	25 May 1941	USA	OK	Harmon				
stevensii	stevensii	TEX	G.J.Goodman/4186	17 May 1947	USA	OK	Blaine				
stevensii	stevensii	GH	G.W.Stevens/590	23 May 1913	USA	OK	Woods				
stevensii	stevensii	TEX	U.T.Waterfall/7107	18 Jun 1947	USA	OK	Harper				
stevensii	stevensii	TEX	U.T.Waterfall/7317	28 Jun 1947	USA	OK	Caddo				
stevensii	stevensii	GH	D.S.Correll/16373	14 May 1957	USA	TX	Fisher				
stevensii	stevensii	GH	D.S.Correll/18605	27 Jul 1957	USA	TX	Winkler				
stevensii	stevensii	GH	D.S.Correll/22027	16 may 1959	USA	TX	Culberson				
stevensii	stevensii	GH	R.McVaugh/8167	4 May 1947	USA	TX	Culberson				
stevensii		GH	U.T.Waterfall/443	8 May 1937	USA	OK	Custer				
stevensii		GH	G.W.Stevens/665	27 May 1913	USA	OK	Woods	Near Alva			

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stevensii		LL	D.S.Correll/22027	16 May 1959	USA	TX	Culberson	Ravine, along Pasotex pipeline, 23 miles east of Delaware Springs			
stevensii		LL	D. S.Correll/38390	8 Apr 1970	USA	TX	Culberson	Rural Rte. #1108, 1.5 mi. SE of US #180. Locally common in gyp soil of box canyon.			
stevensii		TEX	T.Wendt/1119	8/8/75		TX	Briscoe	"Lake Theo State Park property, along old road which leaves 1065 E of Lake Theo, goes down and breaks just E of Holmes Creek, crosses Little Red River and connects to Rte 256; just S of N park boundary, ca 0.8 mi N of Little Red R.; 2450 feet elev."		34.461	100.967
stevensii		LL	D.S.Correll/16373	5/14/57		TX	Fisher	About 1 mile SE of Longworth.			
stevensii		LL	D.S.Correll/18605	7/27/57		TX	Winkler	"Along Hy # 82, 14 miles south of Kermit."			
stevensii		LL	D.S.Correll/19074	7/1/58		TX	Reeves	"In soil with slight amount of gypsum on route #302, 29 miles north of Pecos."			
stevensii		LL	D.S.Correll/22019	5/16/59		TX	Culberson	"Delaware Springs, upper Delaware Creek."			

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stevensii		LL	D.S.Correll/22027	5/16/59		TX	Culberson	"Ravine, along Pasotex pipeine, 23 miles east of Delaware Springs."			
stevensii		LL	D.S.Correll/22097	5/18/59		TX	Kent	"2 miles east of Clairemont, Hy. #380."			
stevensii		LL	D.S.Correll/38390	4/8/70		TX	Culberson	"Rural Rte. #1108, 1.5 mi. SE of US #180."			
stevensii		TEX	R.McVaugh/8167	5/4/47		TX	Culberson	2 miles SE of US routes 62 & 180 at New Mexico line.			
stewartii		GH	I.M.Johnston/814	29 Aug 1940	Mex.	COA		Sierra de las Cruces; south base of Picacho de San Jose			
stewartii		LL-type	I.M.Johnston/	1940	Mex.	COA	ND	Sierra de Cruces S base Picacho San Jos? S base.		27.977	-103.697
torynophylla		LL, TEX	M.C.Johnston/10553 C	3 Apr 1973	Mex.	CHI		1.5 km SE of Rancho Boquillas Perez on the road toward San Luis (which is the Ojinaga-La Perla highway).	1200	29.283	103.267
torynophylla		LL, TEX	M.C.Johnston/12497	7 Apr 1980	Mex.	CHI		Bank of Rio Grande ca 300 meters downstream from Fern Canyon (a tributary of Santa Elena Canyon).			
torynophylla		LL	A.M.Powell/2459	7 Apr 1973	Mex.	CHI	OJINAGA	20 miles W of Ojinaga near CHIH 16; low gravel hills and Cretaceous gypseous clay (yellowish).		29.545	-104.693

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torynophylla		TEX	J.D.Bacon/1150	1971	Mex.	COA	CUATROCI?NEGAS	Cuatroci?negas de Carranza (Cuatroci?negas) 30 mi W of on dirt rd along railrd track to Esmeralda		26.931	-102.524
torynophylla		TEX	M.C.Johnston/12459	1979	Mex.	COA	ND	Sand bar at mouth of Canyon del Caballo (a tributary of R?o Grande)		25.513	-100.613
torynophylla		LL, TEX	J.D.Bacon/1150	16 Oct 1971	Mex.	COA		30 miles West of Cuatro Cienegas on dirt road along Railroad track to Esmeralda. Along roadside in rocky-sandy soil.			
torynophylla		LL, TEX	A.L.Reina/2003-299	14 Mar 2003	Mex.	SON		6.4 km east of Hermosillo on MEX 16; Plains of Sonora desertscrub; disturbed roadside with Pennisetum cilieare.	279	28.990	109.106
torynophylla		GH	C.A.Purpus/124	1902	Mex.			Pena			
torynophylla		TEX	S.Jones/2386	20 Mar 1989	USA	AZ	Yuma				
torynophylla		TEX	A.M.Powell/1313	15 Sep 1964	USA	TX	Presidio	Ca. 20 miles northeast of Redford on Big Bend Ranch.			
torynophylla		TEX	B.L.Turner/21-5	23 Feb 2001	USA	TX	Presidio	7 road miles east of Presidio along highway 170.		29.450	103.800
torynophylla		GH	H.Cutler/21157	4 Mar 1937	USA	TX	Brewster				

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torynophyll a		LL	D.S.Correll/23721	22 Apr 1961	USA	TX	Brewster	"Maravillas Canyon, about 7 miles east of Black Gap Wildlife Preserve."			
torynophyll a		TEX	M.Butterwick/768	8 Jun 1975	USA	TX	Presidio	Infrequent annual herb in gravelly streambed of the Lower Shutup in the Solitario on the Big Bend Ranch.			
torynophyll a		GH	V.L.Cory/s.n.	5 Apr 1939	USA	TX	Brewster				
torynophyll a		LL	D.S.Correll/30697	2/9/65		TX	Brewster	Along Terlingua Creek between Terlingua and Study Butte.			
torynophyll a		LL	D.S.Correll/32640	4/22/66		TX	BREWSTER	"Mouth of Tornillo Creek at Hot Springs on gravel bar, Big Bend National Park."			
torynophyll a		TEX	B.H.Warnock/T639	8/31/38		TX	Brewster	Dog Flats.			
turneri		GH	V.H.Chase/7652	29 Jul 1939	Mex.	NL					
turneri		LL	R.L.McGregor/16688	1961	Mex.	SLP	ND	10 mi N Huizache along Hwy 57		23.067	-100.497
undulata	australis	TEX	B.Sparre/996	28 Nov 1946	Arg.	CAT	Andalgala	Choya - El Tofo, roadside	1400		
undulata	australis	TEX	B.Sparre/8.677	15 Apr 1951	Arg.	RIOJ	Pelagio B. Luna(?)	Sierra Vlazco; Rancho La Esperanza	2100		
undulata	australis	GH	I.M.Johnston/5867	2-3 Jan 1926	Chile	ATA	Vallenar	La Pampa, valley of the Rio del Transito	1450	-27.033	69.783
undulata	australis	GH	Johnston/5867		Chile	ATA	Vallenar	La Pampa, valley of Rio del Transito			
undulata	macrantha	GH	F.W.Pennell/16956	25 Jun 1934	Mex.	NL					

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undulata	macrantha	GH	E.W.Nelson/6697	3 Apr 1902	Mex.	NL					
undulata	macrantha	GH	E.Palmer/143	1 Feb to 9 Apr 1907	Mex.	TAM					
undulata	macrantha	GH	Stanford/2296	5 Jul 1949	Mex.	TAM					
undulata	macrantha	GH	Mrs. E.J.Walker/46	9 Feb 1942	USA	TX		La Jaya			
undulata	macrantha	GH	Berlandier/2116								
undulata	macrantha	GH	Berlandier/2215	Nov 1839							
undulata	macrantha	GH	Berlandier/775 (2195?)	Feb 1831							
undulata	macrantha	GH	illeg/illeg								
undulata	undulata	GH	P.Jorgensen/1052	5 Dec 1915	Arg.	CAT	Andalgala	Comun sobre el rio: Andalgala			
undulata	undulata	GH	P.Cantino/451	21 Nov 1972	Arg.	CAT	Andalgala	4 km E of Andalgala, growing in a wash of a branch of Rio Villavil			
undulata	undulata	GH	Cantino/480	8 Dec 1972	Arg.	CAT	Andalgla	in dry bed of Rio Villavil, 1 km above Villavil.	1300		
undulata	undulata	TEX	B.Turner/9223	2 Feb 1974	Arg.	CAT		Cuesta de la Chilca, NE of Andalgala			
undulata	undulata	GH	Castillon/s.n.	1 Sep 1910	Arg.	CAT	Capital	(Alrededores)			
undulata	undulata	GH	Castillon/s.n.	20 Sep 1910	Arg.	CAT	Capital	Alrededores			
undulata	undulata	GH	EWall/s.n.	28 Nov 1946	Arg.	CAT	Andalgala	Sierra La Negrilla	1500		
undulata	undulata	GH	J.Brizuela/	3 Mar 1950	Arg.	CAT	La Paz	El Bello			
undulata	undulata	GH	S.Venturi/7823	27 Dec 1928	Arg.	CHI	La Rioja	Novogasta	900		
undulata	undulata	GH	Lorentz/14	Jun - Dec 1874	Arg.	COR	Estancia Germania				

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undulata	undulata	GH	Bartlett/19235	8 Dec 1942	Arg.	COR	Serrezuela				
undulata	undulata	GH	W.Lossen/2		Arg.	COR					
undulata	undulata	GH	O'Donell/606	27 Mar 1944	Arg.	COR	Cruz del Eje	C. del Eje			
undulata	undulata	GH	Hunziker/6339	9 Dec 1945	Arg.	COR	Pumilla	? ? Orilla ?ev del Lago Sau Rogue			
undulata	undulata	GH	C.A.O'Donell/775	23 Mar 1944	Arg.	COR	S. Alberto	Cerro La Gloria			
undulata	undulata	GH	Burkart/7750	9 Sept 1936	Arg.	COR	Nono?	La Quebrada, a	900		
undulata	undulata	GH	C.A.O'Donell/929	23 Mar 1944	Arg.	COR	San Alberto	Entre Mina Clavero y Nina Pabla			
undulata	undulata	GH	R.L.Parodi/14813	16 Feb 1944	Arg.	RIOJ		Las Padercitas	700		
undulata	undulata	GH	A.Ruiz Leal/16280	10 Nov 1954	Arg.	RIOJ	Gra?	Begramo, Olta			
undulata	undulata	GH	A.Ruiz Leal/17145	11 Nov 1955	Arg.	RIOJ	Gdor	Gorchillo: Chamical			
undulata	undulata	GH	R.Hauy (?)/26	10 Oct 1941	Arg.	RIOJ	Capital	Camino al Dique K. 9-10	450		
undulata	undulata	GH	Harela/770	11 Dec 1944	Arg.	RIOJ	Grol. Ocompo (?)	Hildgro (?)			
undulata	undulata	GH	A.Ruiz Leal/3429	20 Sep 1937	Arg.	MEN	Las Heras	fr "Rio Qico de las Papagayas"			
undulata	undulata	GH	A.Ruiz Leal/4180	1 Nov 1936	Arg.	MEN	Las Heras	circa "?uina la Atola"			
undulata	undulata	GH	A.Ruiz Leal/8412	6 Feb 1944	Arg.	MEN	Las Heras	El Ghallar			
undulata	undulata	GH	J. U.Araque/19Ar422	25 Nov 1949	Arg.	SL		estacion Alemania	1200		
undulata	undulata	GH	A.R.illeg./2043	19 Nov 1945	Arg.	SJ	Jachul	Las Teunagas(?)			
undulata	undulata	GH	Ramon Diaz/s.n.	7 Nov 1944	Arg.	SE		Camino de Leas Fermas a Santiago			
undulata	undulata	GH	Monetti/1230	10 Oct 1913	Arg.	TUC	Leales	Los Herreras	400		
undulata	undulata	GH	Schrecter/1683	1 Nov	Arg.	TUC		Playa del Rio			

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
				1921				Sali			
undulata	undulata	GH	SVenturi/512	Nov 1919	Arg.	TUC	Leales	Rio Sali	250		
undulata	undulata	GH	Lillo/7527	3 Feb 1908	Arg.	TUC	Tafi	Rio Churqui	2020		
undulata	undulata	GH	Venturi/914	15 Sep 1920	Arg.	TUC	Capital	Rio Sali	500		
undulata	undulata	GH	Lillo/s.n.	Dec 1889	Arg.	TUC	?lurralde				
undulata	undulata	GH	R.B.Maldonado/220	30 Oct 1939	Arg.			Beltran, A. del Cortero (?)			
undulata	undulata	GH	I.M.Johnston/5866	4-5 Jan 1926	Chile	ATA	Vallenar	Above El Chivato; one plant, prostrate; in an old field. Rio de la Laguna Grande, east of Vallenar	2140	28.733	68.050
undulata	undulata	GH	S.S.White/2093	28 Jul 1939	Mex.	CHI					
undulata	undulata	GH	C.G.Pringle/267	2 Apr 185	Mex.	CHI					
undulata	undulata	GH	E.Palmer/377	5-10 Jun 1908	Mex.	CHI					
undulata	undulata	GH	I.MJohnston/8111	11 Aug 1941	Mex.	CHI					
undulata	undulata	GH	F.Shreve/9046	13 Aug 1939	Mex.	CHI					
undulata	undulata	GH	G.B.Hinton/16777	1 May 1949	Mex.	COA					
undulata	undulata	GH	R.M.Stewart/532	14 Jun 1942	Mex.	COA					
undulata	undulata	GH	L.R.Stanford/55	28 Jun 1941	Mex.	COA					
undulata	undulata	GH	R.M.Stewart/577	21 Jun 1941	Mex.	COA					
undulata	undulata	GH	E.Palmer/156	Jun 1896	Mex.	DUR					
undulata	undulata	GH	D.S.Correll/20190	25 Jul 1958	Mex.	DUR					
undulata	undulata	GH	E.Palmer/300	4-25	Mex.	DUR					

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
				Jun 1906							
undulata	undulata	GH	A.Duges/s.n.	Aug 1901	Mex.	GUA					
undulata	undulata	GH	L.A.Kenoyer/1063	22 Jun 1947	Mex.	HID					
undulata	undulata	GH	H.E.Moore, Jr./3739	7 Jul 1948	Mex.	HID					
undulata	undulata	GH	C.L.Hitchcock/7267	23 Jul 1940	Mex.	HID					
undulata	undulata	GH	E.W.Nelson/3882	29 Jun 1896	Mex.	JAL					
undulata	undulata	GH	C.G.Pringle/9379	15 May 1901	Mex.	JAL					
undulata	undulata	GH	??/126	Jun 1888	Mex.	OAX					
undulata	undulata	GH	L.C.Smith/144	18 Jul 1894	Mex.	OAX					
undulata	undulata	GH	W.E.Manning/53903	7 Aug 1953	Mex.	PUE					
undulata	undulata	GH	C.C.Parry/607	1878	Mex.	SLP					
undulata	undulata	GH	J.N.Rose/14666	18 Apr 1910	Mex.	SIN					
undulata	undulata	GH	S.S.White/324	27 Jun 1938	Mex.	SON					
undulata	undulata	GH	C.H.Ramos/267	27 Aug 1968	Mex.	VER					
undulata	undulata	GH	I.M.Johnston/7471	6-8 Sep 1938	Mex.	ZAC					
undulata	undulata	GH	F.Shreve/s.n.	7 Sep 1938	Mex.	ZAC					
undulata	undulata	GH	Bourgeau/731	Jul 1861 (?)	Mex.						
undulata	undulata	GH	V.Havard/95	Sep 1883	USA	TX					
undulata		TEX	A.Reales/1040	24 Feb 1974	Arg.	CAT	Santa Maria	Estancia Totoral			
undulata		TEX	P.R.Legname/196	23 Feb 1974	Arg.	CAT	Belen	Entre Nacimientos de San Antonio y El Bolson	2250		
undulata		TEX	J.Sopaga/3	8 May	Arg.	CAT	La Paz	Icano La Paz			

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
				1950							
undulata		TEX	G.Borsini/1122	8 Jan 1950	Arg.	COR	Coton	La Grouja(?)			
undulata		TEX	B.Baleyun/1217	26 Dec 1946	Arg.	COR	Gulumba(?)	Dean(?) Funes			
undulata		TEX	M.Villafane/184	29 Dec 1946	Arg.	COR	Cruz del Eje	Cruz del Eje			
undulata		TEX	A.De la Sota/3665	5 Jan 1951	Arg.	COR	Cruz del Eje	Dique Cruz del Eje			
undulata		TEX	A.Richardson/2020	8 Feb 1973	Arg.	MEN		Paramillo, ca. 3 km from Hwy toward Mendoza; roadside			
undulata		TEX	F.Martinez M./38	1958	Mex.	CHI	Chihuahua	La Campana (Chihuahua - Chihuahua)		29.267	-106.356
undulata		TEX	A.Lee/40	1946	Mex.	CHI	Chihuahua	30 mi NW of Chihuahua		28.995	-106.308
undulata		TEX	M.H.Mayfield/274	1989	Mex.	CHI	BUENAVENTURA	SW of San Buenaventura along jeep rd leading from El Rancho de la Tinaja to R?o Santa Mar?a (roughly E/W ca 12 mi). Near tributaries of R?o Santa Mar?a		29.844	-107.472
undulata		TEX	J.Spencer/445	1997	Mex.	CHI	CASAS GRANDES	Sierra La Bre±a		30.079	-108.130
undulata		TEX	H.LeSueur/869	1936	Mex.	CHI	Chihuahua	Mts NW of Chihuahua City		28.635	-106.089
undulata		TEX	T.F.Stuessy/1017	1967	Mex.	CHI	Hidalgo DEL PARRAL	2.5 mi W of Hidalgo del Parral		26.937	-105.696
undulata		LL	A.F.Moldenke/2098	1967	Mex.	CHI	AHUMADA	Miguel Ahumada		29.874	-106.393
undulata		LL	I.M.Johnston/8111	1941	Mex.	CHI	OJINAGA	Vicinity of Pirßmide 3 mi S of Pirßmide		28.804	-104.196

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
undulata		LL	M.C.Johnston/11412	1973	Mex.	CHI	ND	S side of Lago Toronto 24.5 Km from El Tigre and 52 Km from Valle de Zaragoza on winding rd (Chihuahua - ND)		27.467	-105.500
undulata		LL	J.Dwyer/14241	1977	Mex.	CHI	CAMARGO	MIdway between Cd Camargo and JIm?nez Chihuahua-Durango border		27.451	-104.490
undulata		LL	D.S.Correll/21456	1959	Mex.	CHI	JIM?NEZ	Escal?n 10 mi NW sobre la carretera Libre Federal No. 49 (pavim. 2 carriles)		26.837	-104.473
undulata		LL	D.S.Correll/21508	1959	Mex.	CHI	SAN FRANCISCO DEL ORO	N of San Francisco del Oro		26.859	-105.848
undulata		LL	D.S.Correll/21523	1959	Mex.	CHI	Hidalgo DEL PARRAL	Hidalgo del Parral		26.977	-105.482
undulata		LL	D.S.Correll/21730	1959	Mex.	CHI	Chihuahua	Entronque el Sauz Kilometro Cincuenta y Cuatro		29.052	-106.328
undulata		LL	R.M.Stewart/532	1941	Mex.	COA	ND	Vicinity of Rancho El Tule S foothills of the igneous Sa Hechiceros; about 24 Km due N of Castillon and close to the Chihuahuan boundary		26.340	-101.370

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
undulata		LL	R.M.Stewart/577	1941	Mex.	COA	SIERRA MOJADA	Sierra de las Cruses (Ca±on de Tinaja Blanca E slope of the igneous central mass of the Sa de Las Cruces W of Santa Elena Mines)		27.977	-103.697
undulata		TEX	G.B.Hinton/18915	1985	Mex.	COA	ARTEAGA	Sierra El Coahuil?n		25.245	-100.349
undulata		GH	E.Palmer/858	Feb to Oct 1880	Mex.	COA					
undulata		TEX	R.Corral D./284	1983	Mex.	DUR	SANTIAGO PAPASQUIARO	Santiago Papasquiaro N edge of town along Hwy to Los Herreras		25.044	-105.419
undulata		TEX	R.Hernßndez M./7993	1982	Mex.	DUR	SANTIAGO PAPASQUIARO	Santiago Papasquiaro Alrededores		25.044	-105.419
undulata		LL	M.C.Johnston/10420	1973	Mex.	DUR	ND	Estaci?n Microondas Sapioris ca 30 Km SW of G?mez Palacio on Hwy toward Durango		25.408	-103.717
undulata		TEX	J.S.Wilson/11299	1966	Mex.	DUR	Durango	Durango city 84 m E		23.551	-103.640
undulata		TEX	J.S.Wilson/11312	1966	Mex.	DUR	Durango	Durango city 63 mi E on Hwy 40		24.639	-103.958
undulata		LL	D.S.Correll/20190	1958	Mex.	DUR	Durango	Durango city 24 mi NE rte 40		24.270	-104.414
undulata		TEX	F.A.Barkley/7261B	1947	Mex.	MEX	TEOTIHUAC?N	Zona Arqueol?gica Teotihuacßn (Templo de Quetzalcoatl)		19.692	-98.843

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
undulata		TEX	J.Rzedowski/16990	1963	Mex.	HID	TEPEAPULCO	Fray Bernardino de Sahag·n (Ciudad Sahag·n) 2 Km N sobre la carretera a Tlanalapa.		19.786	-98.588
undulata		TEX	G.B.Hinton/24215	1994	Mex.	NL	MONTEMORELOS	Montemorelos 23.815 Km al SW rumbo a Rayones.		25.050	-99.926
undulata		TEX	F.A.Barkley/794	1947	Mex.	SLP	SAN LUIS POTOS?	4 mi NE of SLP		22.197	-100.938
undulata		GH	J.G.Schaffner/78	Aug 1876	Mex.	SLP					
undulata		TEX	A.C.Sanders/3695	1983	Mex.	SON	ND	El Caracol Trailer Park 9 mi W of Alamos on the rd to Navajoa		27.067	-109.067
undulata		TEX	R.Runyon/930	1926	Mex.	TAM	VICTORIA	Ciudad Victoria cerca de.		23.736	-99.146
undulata		TEX	M.Nee/32973	1986	Mex.	VER	PEROTE	7 Km NW of Perote on rd to Frijol Colorado		19.583	-97.317
undulata		TEX	U.T.Waterfall/13812	1957	Mex.	ZAC	FRESNILLO	Fresnillo 30 mi NW por la carretera Libre Federal No. 45 (pavimen. 2 carriles)		23.530	-103.145
undulata		LL	M.C.Johnston/10455-C	1973	Mex.	ZAC	ND	1.5 Km W of Caopas		24.778	-102.183
undulata		TEX	M.Butterwick/3749	6/5/77		TX	Presidio	"At the mouth of Dead Horse Canyon, on the north side of Chinanti Peak. Elevation ca. 4900 ft."			

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
whalenii		TEX	T.L.Wendt/1838	29 sep 1976	Mex.	COA	OCAMPO	From Rancho Cerro de la Madera 8.6 mi W by rd Ca±?n Desiderio (N draining): 0.25 mi below (NE of) jct of E and W forks along lumber rd		27.135	-102.545
whalenii		TEX	I.M.Johnston/9029	1941	Mex.	COA	ND	Sa de la Madera: high crest of main ridge about 2 Km E of Picacho de Zozaya		27.000	-102.301
whalenii		TEX	J.S.Henrickson/13134-B	1973	Mex.	COA	ND	Ca 26 (air) mi SE of Torre?n in Sa de Jimulco ca 6 (air) mi SSW of La Rosita along trail to summit 1.5 mi above rds end above main NE-SW running canyon (Coahuila - ND)		25.167	-103.250
whalenii		LL	F.Chiang C/9547B	1972	Mex.	COA	CUATROCI?NEGAS	Sa de Jimulco and up to 3 Km N of Mina San Jos? wich is 8 Km NE of Estaci?n OTTO		25.108	-103.225
whalenii		LL	F.Chiang C/9555e	1972	Mex.	COA	TORRE?N	OTTO (Estaci?n) 8 Km NE of Sierra de Jimulco and up to 3 Km N of Mina San Jos? wich is		25.134	-103.231

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
whalenii		TEX	McDonald/2074	1986	Mex.	NL	GENERAL ZARAGOZA	Pe±a Nevada Sierra (Nuevo Leon - GENERAL ZARAGOZA)		23.802	-99.845
whalenii		TEX	C.P.Cowan/5470	1985	Mex.	QUE	CADEREYTA DE MONTES	0.7 mi (1.1 Km) S of Higuerillas on dirt rd (terracer?a) S of Hwy (Higuerillas-San Pablo Tolimßn)		20.916	-99.757
xylopoda		GH	A.L.Hershey/3042	23 May 1944	USA	NM	Eddy				
xylopoda		TEX	T.F.Patterson/556	19 Oct 1973	UsA	NM	Otero				
xylopoda		GH	B.H.Warnock/122	15 Sep 1948	USA	TX	Culberson				
xylopoda		GH	V. Howard/15 1/2	1882	USA	TX					
xylopoda		GH	D.S.Correll/18477	25 Jul 1957	USA	TX	Culberson				
xylopoda		GH	J.A.Moore/3562	22 Jul 1931	USA	TX	Culberson				
xylopoda			U.T.Waterfall/4533	15 Jun 1943	USA	TX	Culberson				
xylopoda		GH	C.L.Lehman/s.n.	28 Jun 1939	USA	TX	Culberson				
xylopoda		GH	M.S.Young/s.n.	14 Aug 1916	USA	TX					
xylopoda		LL	D.H.Riskind/1058			TX	Culberson	Guadalupe Mts. National Park.			
xylopoda		TEX	B.H.Warnock/122	9/15/48		TX	Culberson	Smith Canyon. Alt. 5500 feet. Guadalupe Mountains.			
xylopoda		LL	C.L.Lundell/14391	8/9/45		TX	Culberson	"Guadalupe Mountains, above Lajitas."			
xylopoda		LL	D.S.Correll/18477	7/25/57		TX	Culberson	"North Fork of McKittrick Canyon,			

Species	Variety	Herb	Collector Name/No.	Coll. Date	Country	State	County	Locality Detail	Elev. (m)	Lat. (dec. deg)	Long (dec. deg)
								Guadalupe Mts."			
xylopoda		LL	D.S.Correll/24277	9/7/61		TX	Culberson	Pine Springs Canyon. Guadalupe Mts.			
xylopoda		LL	D.S.Correll/26085	9/29/62		TX	Culberson	"Guadalupe Mts., south fork of McKittrick Canyon, J.C. Hunter ranch; crevice of ledge."			
xylopoda		LL	S.Sikes/533	6/12/73		TX	Culberson	"Radio Tower Hill, Victorio Wildlife Management Area, Sierra Diablo Mountains."			
xylopoda		TEX	M.S.Young/s.n.	8/15/16		TX	Culberson	Guadalupe Mt.			

References

Albach, D.C., P.S. Soltis, D.E. Soltis, and R.G. Olmstead. 2001. Phylogenetic analysis of Asterids based on sequences of four genes. *Annals of the Missouri Botanical Garden* 88(2): 163-212.

Alvarez, I. and J. F. Wendel. 2003. Ribosomal ITS sequences and plant phylogenetic inference. *Molecular Phylogenetics and Evolution* 29(3): 417-434.

Anderson, R.C., J.S. Fralish, and J.M. Baskin, eds. 1999. *Savannas, Barrens, and Rock Outcrop Plant Communities of North America*. Cambridge University Press, New York, NY.

APG I. 1998. An ordinal classification for the families of flowering plants. *Annals of the Missouri Botanical Garden* 85(4): 531-553.

APG II. 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnaean Society* 141: 399-436.

APG III. 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* 161: 105-121.

Arthur, J.C., J.H. Barnhart, N.L. Britton, F.E. Clements, O.F. Cook, F.V. Coville, F.S. Earle, A.W. Evans, T.E. Hazen, A. Hollick, M.A. Howe, F.H. Knowlton, G.T. Moore, HH. Rusby, C.L. Shear, L.M. Undewood, D. White, and W.F. Wight. 1907. American Code of Botanical Nomenclature. *Bulletin of the Torrey Botanical Club* 34(4): 167-178.

Averett, J.E. and M. Powell. 1976. A new gypsophilous species of Gaillardia (Asteraceae) from Chihuahua, Mexico. *Annals of the Missouri Botanical Garden* 63(2): 375-377.

Bacon, J.D. 1974. Chromosome numbers and taxonomic notes in the genus *Nama* (Hydrophyllaceae). *Brittonia* 26(2): 101-105.

Bacon, J.D. 1981. New species of *Nama* (Hydrophyllaceae) from the Chihuahuan Desert region of Mexico. *Sida* 9(2): 99-103.

Bacon, J.D. 1984. Chromosome numbers and taxonomic notes in the genus *Nama* (Hydrophyllaceae). II. Sida 10(4): 269-275.

Bacon, J.D. 1987. Systematics of *Nama* (Hydrophyllaceae): seed coat morphology of *Lemmonia californica* and *Nama* species allied with *Nama demissum*. *Aliso* 11: 441-450.

Bacon, J.D. and J.A. McDonald. 1991. *Nama quiexobranum* (Hydrophyllaceae): a new species from Oaxaca, Mexico. *Phytologia* 70(1): 21-23.

Baldwin, B.G., M.J. Sanderson, J.M. Porter, M.F. Wojciechowski, C.S. Campbell, and M.J. Donoghue. 1995. The ITS Region of nuclear ribosomal DNA: A Valuable Source of evidence on angiosperm phylogeny. *Annals of the Missouri Botanical Garden* 82(2): 247-277.

Binder, B.F. 1989. *The Chemistry and biology of insect growth regulators from plants in the genus* Nama *(Hydrophyllaceae).* Ph.D. Dissertation, The University of Arizona Graduate Program in Entomology.

Blackwell, W.H. 2002. One-Hundred-Year Code deja vu? *Taxon* 51(1): 151-154.

Bogdanovic, M., M. Sabovljevic, A. Sabovljevic, and D. Grubisic. 2009. The influence of gypsiferous substrata on bryophyte growth: are there obligatory gypsophilous bryophytes? *Botanica Serbica* 33(1): 75-82.

Borselli, L., R. Biancalani, C. Girodani, S. Carnicelli, and G.A. Ferrari. 1996. Effect of gypsum on seedling emergence in a kaolinitic crusting soil. *Soil Technology* 9: 71-81.

Bradshaw, A.D., and T. McNeilly. 1981. *Evolution and Pollution*. Institute of Biology, London, UK.

Brand, A. 1913. Hydrophyllaceae. In *Das Pflanzenreich. Regni vegetabilis conspectus IV.251*. A. Engler, ed. 1-210. Wilhelm Engelmann, Leipzig, Germany.

Bridges, E.M. and C.P. Burnham. 1980. Soils of the state of Bahrain. *Journal of Soil Science.* 31: 689-707.

Britton, N.L. and A. Brown. 1913. *An Illustrated Flora of the Northern United States, Canada and the British Posessions.* Charles Scribner's Sons, New York, NY.

Browne, P. 1756. *The Civil and Natural History of Jamaica.* T. Osborne and J. Shipton, London, UK.

Campbell, R.S. and I.F. Campbell. 1938. Vegetation on gypsum soils of the Jornada Plain, New Mexico. *Ecology* 19: 572-577.

Candolle, A.L. De. 1867. *Lois de la Nomenclature botanique adoptees par le Congres a Paris en Aout 1867*. J.B. Bailliere et fils, Paris.

Carlquist, S. 1967. The Biota of Long-Distance Dispersal. V. Plant Dispersal to Pacific Islands. *Bulletin of the Torrey Botanical Club* 94(3): 129-162.

Cavanilles, A.J. 1795. *Observaciones sobre la Historia Natural, Geografia, Agricultura, Poblacion y Frutos del Reyno de Valencia*. La Imprenta Real (D. Pedro Julian Pereyra), Madrid.

Cave, M.S. and L. Constance. 1947. Chromosome numbers in the Hydrophyllaceae: III. *University of California Publications in Botany* 18: 449-465.

Cave, M.S. and L. Constance. 1950. Chromosome numbers in the Hydrophyllaceae: IV. *University of California Publications in Botany* 23: 363-382.

Cave, M.S. and L. Constance. 1959. Chromosome numbers in the Hydrophyllaceae: V. *University of California Publications in Botany* 30: 233-258.

Chance, G.D. and J.D. Bacon. 1984. Systematic implications of seed coat morphology in *Nama* (Hydrophyllaceae. *American Journal of Botany* 71(6): 829-842.

Choisy, J.D. 1833. Genus *Nama* (Des Hydroleacees). *Memoires de la Societe de Physique et D'Histoire Naturelle de Geneve* 6: 111-115.

Choisy, J.D. 1846. Hydroleaceae. In *Prodromus Systematis Naturalis Regni Vegetabilis*, A. de Candolle, ed. 179-185. Treuttel and Wurtz, Paris.

Cosner, M.E., R.K. Jansen, and T.G. Lammers. 1994. Phylogenetic relationships in the Campanulales based on *rbc*L sequences. *Plant Systematics and Evolution* 190(1-2): 79-95.

Dicht, R.F. and A.D. Luthy. 2005. *Coryphantha: Cacti of Mexico and Southern USA*. Springer-Verlag, Berlin, Germany.

Diers, L. 1961. Der anteil an polyploiden in den vegetationsgurteln der WestKordillere Perus. *Botanische Zeitung* 49: 437-488.

Dobzhansky, T.G. 1941. *Genetics and the Origin of Species*. Columbia University Press, New York.

Donaldson, J.R. and R.G. Cates. 2004. Screening for anticancer agents from Sonoran Desert plants: a chemical ecology approach. *Pharmaceutical Biology* 42(7): 478-487.

Douglas, N.A. and P.S. Manos. 2007. Molecular phylogeny of Nyctaginaceae: Taxonomy, biogeography, and characters associated with a radiation of xerophytic genera in North America. *American Journal of Botany* 94(5): 856-872.

Doyle, J.J. and E.E. Dickson. 1987. Preservation of Plant Samples for DNA Restriction Endonuclease Analysis. *Taxon* 36(4): 715.

Drohan, P.J. and D.J. Merkler. 2009. How do we find a true gypsophile? *Geoderma* 150(1-2): 96-105.

Duvigneaud, P. and S. Denaeyer-DeSmet. 1968. Essai de classification chimique (elements mineraux) des plantes gypsicolas du Bassin de l'Ebre. *Bulletin de la Societe Royale de Botanique de Belgique* 101: 279-291.

Earle, F.S. 1905. Nomenclature at the International Botanical Congress at Vienna. *Science, New Series* 22(563): 468-469.

Edgar, R.C. 2004. MUSCLE: multiple sequence alignment with high accuracy and high throughput. *Nucleic Acids Research* 32(5): 1792-1797.

Emerson, F.W. 1935. An ecological reconnaissance in the White Sands, New Mexico. *Ecology* 16(2): 226-233.

Escudero, A. R. Somolinos, J.M. Olano, and A. Rubio. 1999. Factors controlling the establishment of *Helianthemum squamatum*, and endemic gypsophile of semi-arid Spain. *Journal of Ecology* 87: 290-302.

Escudero, A., J.M. Iriondo, J.M. Olano, A. Rubio, and R.C. Somolinos. 2000. Factors affecting establishment of a gypsophyte: the case of *Lepidium subulatum* (Brassicaceae). *American Journal of Botany* 87: 861-871.

Farris, J.S., M. Kallersjo, A.G. Kluge, and C. Bult. 1994. Testing significance of incongruence. *Cladistics* 10(3): 315-319.

Feliner, G.N. and J.A. Rosselló. 2007. Better the devil you know? Guidelines for insightful utilization of nrDNA ITS in species-level evolutionary studies in plants. *Molecular Phylogenetics and Evolution* 44(2): 911-919.

Ferguson, D.M. 1998a. Phylogenetic Systematics of Hydrophyllaceae. Ph.D. Dissertation, Department of Organismic and Evolutionary Biology, Harvard University.

Ferguson, D.M. 1998b. Phylogenetic analysis and relationships in Hydrophyllaceae based on *ndh*F sequence data. *Systematic Botany* 23(3): 253-268.

Gankin, R. and J. Major. 1964. *Arctostaphylos myrtifolia*, its biology and relationship to the problem of endemism. *Ecology* 45(4): 792-808.

Goldman, N., J.P. Anderson, and G. Rodrigo. 2000. Likelihood-based tests of topologies in phylogenetics. *Systematic Biology* 49(4): 652-70.

Goleniowski, M.E., G.A. Bongiovanni, L. Palacio, C.O. Nunez, and J.J. Cantero. 2006. Medicinal plants from the "Sierra de Comechingones," Argentina. *Journal of Ethnopharmacology* 107(3): 324-341.

Gottschling, M., H.H. Hilger, M. Wolf, and N. Diane. 2001. Secondary structure of the ITS1 transcript and its application in a reconstruction of the phylogeny of Boraginales. *Plant Biology* 3: 629-636.

Gray, A. 1861. Characters of new or obscure species of plants of monopetalous orders in the collection of the United States South Pacific Exploring Expedition under Captain Charles Wilkes, U.S.N. With occasional remarks, &c. *Proceedings of the American Academy of Arts and Sciences* 5: 321-339.

Gray, A. 1870. Miscellaneous botanical notes and characters (*Nama*). *Proceedings of the American Academy of Arts and Sciences* 8: 282-332.

Gray, A. 1875. A conspectus of the North American Hydrophyllaceae. *Proceedings of the American Academy of Arts and Sciences* 10: 312-332.

Gray, A. 1882. *Nama*. In *Biologia Central-Americana: Botany vol. 2*, ed. W.B. Hemsley, 360-366.

Gunn, M. and L.E.W. Codd. 1981. *Botanical exploration of Southern Africa: an illustrated history of early botanical literature on the Cape flora*. CRC Press, Pretoria, South Africa.

Harpke, D. and A Peterson. 2008. 5.8S motifs for the identification of pseudogenic ITS regions. *Botany* 86: 300-305.

Harris, J.G. and M.W. Harris. 1994. *Plant Identification Terminology: An Illustrated Guide.* Spring Lake Publishing, Payson, Utah.

Heller, A.A. 1898. *Catalogue of North American Plants North of Mexico, Exclusive of the Lower Cryptograms*. Published by the author, Lancaster, PA.

Henrickson, J. 1976. *Marshalljohnstonia*, a new genus (Asteraceae) with a rosette-shrub growth habit from Mexico. *Systematic Botany* 1(2): 169-180.

Henrickson, J. 1977. Saline habitats and halophytic vegetation of the Chihuahuan Desert Region. In *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico (1974: Sul Ross University)*, R.H. Wauer and D. H. Riskind, eds. p. 289-314. U.S. Dept. of the Interior, National Park Service, Washington, DC.

Henrickson, J. and M.C. Johnston. 1986. Vegetation and community types of the Chihuahuan Desert. p. 20-39. In *Invited Papers from the Second Symposium on Resources of the Chihuahuan Desert Region, United States and Mexico, 20-21 Oct 1983*. J.C. Barlow, A.M. Powell, and B.N. Timmermann, eds. Chihuahuan Desert Research Institute, Alpine, TX.

Hickey, M. and C. King. 2001. *The Cambridge Illustrated Glossary of Botanical Terms.* Cambridge University Press. Cambridge, UK.

Hipp, A., J. Hall, and K. Sytsma. 2004. Congruence versus phylogenetic accuracy: revisiting the incongruence length difference test. *Systematic Biology* 53(1); 81-89.

Hitchcock, C.L. 1933a. A taxonomic study of the genus *Nama*. I. *American Journal of Botany* 20(6): 415-430.

Hitchcock, C.L. 1933. A taxonomic study of the genus *Nama*. II. *American Journal of Botany* 20(8): 518-534.

Hitchcock, C.L. 1939. The perennial Mexican Namas. *American Journal of Botany* 26(5): 341-347.

Huelsenbeck, J.P. and F. Ronquist. 2001. MRBAYES: Bayesian inference of phylogeny. *Bioinformatics* 17: 754-755.

Humphrey, W.E., and T. Diaz, 2003. *Report of Investigations No. 267: Jurassic and Lower Cretaceous Stratigraphy and Tectonics of Northeast Mexico*. J.L. Wilson and C. Jordan, eds. Bureau of Economic Geology, University of Texas at Austin, Texas.

IUSS Working Group WRB. 2006. *World reference base for soil resources 2006*. 2nd edition. World Soil Resources Reports No. 103. FAO, Rome.

Jain, S.K., and A.D. Bradshaw. 1966. Evolutionary divergence among adjacent plant populations. I. The evidence and its theoretical analysis. *Heredity* 20: 407-441.

Jepson, W.L. 1925. *Manual of the Flowering Plants of California*. Berkeley, California: University of California.

Johnson, K.S., S. Gonzales, and W. E. Dean. 1989. Distribution and geologic characteristics of anhydrite deposits in the United States. In *Anhydrite Deposits of the United States and Characteristics of Anhydrite Important for Storage of Radioactive Wastes. USGS Bulletin 1794*, ed. Walter E. Dean and KS Johnson, 9-90. U.S. Geological Survey, Denver, Colorado.

Johnson, L.A. and D.E. Soltis. 1994. *mat*K DNA sequences and phylogenetic reconstruction in Saxifragaceae *s. str*. *Systematic Botany* 19(1): 143-156.

Johnson, L.A. and D.E. Soltis. 1995. Phylogenetic inference in Saxifragaceae *sensu stricto* and *Gilia* (Polemoniaceae) using *mat*K sequences. *Annals of the Missouri Botanical Garden* 82(2):149.

Johnson, L.A. and D.E. Soltis. 1998. Assessing congruence: Empirical examples from molecular data. In *Molecular Systematics of Plants II: DNA Sequencing*, ed. D.E. Soltis, P.S. Soltis, and J.J. Doyle, 297-348. Kluwer Academic Publishers, Norwell, Massachusetts.

Johnston, I.M. 1941. Gypsophily among Mexican desert plants. *Journal of the Arnold Arboretum* 22(2):145-170.

Johnston, I.M. 1941. New phanerogams from Mexico, IV. *Journal of the Arnold Arboretum* 22(1): 110-125.

Jussieu, A.L. De. 1789. *Genera Plantarum Secundum Ordines Naturales Disposita, 1st ed.* Herissant and Barrois, Paris.

Kelchner, S.A. 2002. Group II introns as phylogenetic tools: structure, function, and evolutionary constraints. *American Journal of Botany* 89(10): 1651-1669.

Kim, K-J. and R.K. Jansen. 1995. *ndh*F sequence evolution and the major clades in the sunflower family. *Proceedings of the National Academy of Sciences* 92: 10379-10383.

Kishino, H. and M. Hasegawa. 1989. Evaluation of the maximum likelihood estimates of the evolutionary tree topologies from sequence data, and the branching order in Homonoidea. *Journal of Molecular Evolution* 29:170-179.

Kruckeberg, A.R. 1969. Soil diversity and the distribution of plants, with examples from western North America. *Madrono* 20(3): 129-154.

Kruckeberg, A.R. 2002. The influences of lithology on plant life. In *Geology and Plant Life: the Effects of Landforms and Rock Types on Plants*, 103-228. University of Washington Press, Seattle, Washington.

Kruckeberg, A.R. and D. Rabinowitz. 1985. Biological aspects of endemism in higher plants. *Annual Review of Ecology and Systematics* 16: 447-479.

Kuntze, O. 1891. *Revisio Generum Plantarum, vol. 2*. Arthur Felix, Leipzig.

Kuzmanov, B. and V. Nikolova. 1977. IOPB chromosome number reports LVIII. *Taxon* 26: 557-565.

Lawrence, G.H.M. 1963. *Taxonomy of Vascular Pants*. The MacMillan Company: New York.

Liddell, H.G. and R. Scott. 1940. *A Greek-English Lexicon*. Clarendon Press: Oxford, UK.

Link, H.F. 1789. Florae Gottingensis specimen, sistens vegetabilia saxo calcareo propria. *In* Usteri's *Delectus Opusculoruni Botanicorum*, vol. 1, pp. 299-336.

Linnaeus, C. 1735. *Systema naturæ, sive regna tria naturæ systematice proposita per classes, ordines, genera, & species.* Lugduni Batavorum. (Haak).

Linnaeus, C. 1747. *Flora Zeylanica.* 1045, Pl. 117.

Linnaeus, C. 1753. *Species Plantarum*, ed. I: 226.

Linnaeus, C. 1759. *Systema Naturae*, ed. 10. 2: 950.

MacBride, J.F. 1917. Notes on the Hydrophyllaceae and a few other North American spermatophytes. *Contributions of the Gray Herbarium of Harvard University* 49: 23-59.

Maddison, D.R. and W.P.Maddison. 2000. MacClade 4: Analysis of phylogeny and character evolution. Sinauer Associates: Sunderland, Massachusetts.

Manara, B. 1991. Some guidelines on the use of gender in generic names and species epithets. *Taxon* 40(2): 301-308.

Martínez-Montoya, J.F., J. Herrero, and M.A. Casterad. 2010. Mapping categories of gypseous lands in Mexico and Spain using Landsat imagery. *Journal of Arid Environments* 74(8): 978-986.

Mason, H.L. 1946. The edaphic factor in narrow endemism. II. The geographic occurrence of plants of highly restricted patterns of distribution. *Madrono* 8: 241-257.

Mason-Gamer, R.J., C.F.Weil, and E.A. Kellogg. 1998. Granule-Bound Starch Synthase: structure, function, and phylogenetic utility. *Molecular Biology and Evolution* 15(12): 1658-1673.

Mayr, E. 1942. *Systematics and the Origin of Species*. Columbia University Press: New York.

McDill, J., M, Repplinger, B.B. Simpson, and J.W. Kadereit. 2009. The Phylogeny of *Linum* and Linaceae subfamily Linoideae, with implications for their systematics, biogeography, and evolution of heterostyly. *Systematic Botany* 34(2): 386-405.

McNeill, J., F.R. Barrie, H.M. Burdet, V. Demoulin, D.L. Hawksworth, K. Marhold, D.H. Nicolson, et al. 2006. International Code of Botanical Nomenclature (Vienna Code). In *Regnum Vegetabile 146*. A.R.G. Gantner Verlag KG.

McNeilly, T. and J. Antonovics. 1968. Evolution in closely adjacent plant populations. IV. Barriers to gene flow. *Heredity* 23: 205-218.

McNeilly, T. and A.D. Bradshaw. 1968. Evolutionary processes in populations of copper tolerant *Agrostis tensuis* Sibth. *Evolution* 22(1): 108-118.

Meyer, S.E. 1986. The ecology of gypsophiles endemism in the eastern Mojave Desert. *Ecology* 67(5): 1303-1313.

Meyer, S.E, E. Garcia-Moya, and L. del Carmen Lagunes-Espinoza. 1992. Topographic and soil surface effects on gypsophile plant community patterns in central Mexico. *Journal of Vegetation Science* 3(4): 429-438.

Miller, M.A., W. Pfeiffer, and T. Schwartz. 2010. Creating the CIPRES Science Gateway for inference of large phylogenetic trees. In *Proceedings of the Gateway Computing Environments Workshop (GCE), 14 Nov 2010*, 1-8. New Orleans, Louisiana.

Moerman, D.E. 2009. *Native American Medicinal Plants: an Ethnobotanical Dictionary*. Timber Press, Inc: Portland, Oregon.

Moore, M.J. 2005. *Molecular Systematics of* Tiquilia *(Boraginaceae): Age, Origin, Dispersal History, and Gypsophilic Evolution.* Ph.D. Dissertation, The University of Texas at Austin.

Moore, M.J. and R. K. Jansen. 2006. Molecular evidence for the age, origin, and evolutionary history of the American desert plant genus *Tiquilia* (Boraginaceae). *Molecular Phylogenetics and Evolution* 39(3): 668-87.

Moore, M.J. and R.K. Jansen. 2007. Origins and biogeography of gypsophily in the Chihuahuan Desert plant group *Tiquilia* subg. *Eddya* (Boraginaceae). *Systematic Botany* 32(2): 392-414.

Moore, M. J, P.S. Soltis, C.D. Bell, J.G. Burleigh, and D.E. Soltis. 2010. Phylogenetic analysis of 83 plastid genes further resolves the early diversification of eudicots.

Proceedings of the National Academy of Sciences of the United States of America 107(10): 4623-4628.

Mota, J.F., A. J. Sola, M.L. Jiménez-Sánchez, F.J. Pérez-García, and M.E. Merlo. 2004. Gypsicolous flora, conservation and restoration of quarries in the southeast of the Iberian Peninsula. *Biodiversity and Conservation* 13: 1797-1808.

Mota, J.F., P.S. Gomez, M.E.M. Calvente, P.C. Rodriguez, E.L. Lumbreras, M. de La Cruz Rot, F.B. Navarro Reyes, F.M. Gallardo, C.B. Estaban, J.M.M Labarga, H. S. Ollero, F.V. Tendero, L. S. Laliga, F.M. Hernandez, J.A. Garrido Becerra, and F.J. Perez Garcia. 2009. Aproximación a la checklist de los gipsófitos ibéricos. *Anales de Biologia* 31: 71-80.

Murray, R.C. 1964. Origin and diagenesis of gypsum and anhydrate. *Journal of Sedimentary Research* 34(3): 512-523.

Nash, D.L. 1979. *Nama linearis. Flora de Veracruz* 5: 16-17.

Nesom, G.L., Y. Suh, D.R. Morgan, and B.B. Simpson. 1990. *Xylothamia* (Asteraceae: Astereae), a new genus related to *Euthamia. Sida* 14(1): 101-116.

Nesom, G.L. 1991. A new species of *Nama* (Hydrophyllaceae) from northeastern Mexico. *Phytologia* 71(5): 357-359.

Nesom, G.L. 1992a. A new gypsophilic species of *Xylothamia* (Asteraceae: Astereae) from the Cuatro Cienegas area of Coahuila, Mexico. *Phytologia* 73(4): 318-320.

Nesom, G.L. 1992b. A new species of *Nama* from the Cuatro Cienegas area of Coahuila, Mexico. *Phytologia* 73(1): 61-63.

Nesom, G.L. 1993. *Leucophyllum alejandrae* (Scrophulariaceae), a new gypsophilic species from Nuevo Leon, Mexico. *Phytologia* 74(4): 293-295.

Nettleton, W.D., R.E. Nelson, B.R. Brasher, and P.S. Derr. 1982. Gypsiferous soils in the western United States. In *Acid sulfate weathering*, ed. J.A. Kittrick, D.S. Fanning, L.R. Hossner, D.M. Kral, and S. Hawkins, 147-168. SSSA Special Publication Number 10. Soil Science Society of America: Madison, Wisconsin.

Nicolson, D.H. 1991. A History of Botanical Nomenclature. *Annals of the Missouri Botanical Garden* 78(1): 33-56.

Nicolson, D.H. 1994. Gender of generic names, particularly those ending in –ma, in the 'Names in Current Use' list. *Taxon* 43(1): 97-107.

Nylander, J.A.A. 2004. MrModeltest. Evolutionary Biology Centre, Uppsala University: Program distributed by the author.

Olmstead, R.G, B. Bremer, K.M. Scott, and J.D. Palmer. 1993. A parsimony analysis of the Asteridae sensu lato based on *rbc*L sequences. *Annals of the Missouri Botanical Garden* 80(3): 700-722.

Olmstead, R.G. and D.M. Ferguson. 2001. A molecular phylogeny of the Boraginaceae-Hydrophyllaceae. In *Botany 2001: plants and people, Abstracts*, 131. Columbus, Ohio: Botanical Society of America.

Olmstead, R.G. and P.A. Reeves. 1995. Evidence for the polyphyly of the Scrophulariaceae based on chloroplast rbcL and ndhF sequences. *Annals of the Missouri Botanical Garden* 82: 176-193.

Olmstead, R.G. and J.A. Sweere. 1994. Combining data in phylogenetic systematics: an empirical approach using three molecular data sets in the Solanaceae. *Systematic Biology* 43(4): 467-481.

Ornduff, R. 1965. Ornithocoprophilous Endemism in Pacific Basin Angiosperms. *Ecology* 46(6): 864-867.

Palacio, S., A. Escudero, G. Montserrat-Martí, M.Maestro, R. Milla, and M.J. Albert. 2007. Plants living on gypsum: beyond the specialist model. *Annals of Botany* 99: 333-343.

Park, S. -J., E.J. Korompai, J. Francisco-Ortega, A. Santos-Guerra, and R.K. Jansen. 2001. Phylogenetic relationships of *Tolpis* (Asteraceae: Lactuceae) based on n*dh*F sequence data. *Plant Systematics and Evolution* 226: 23-33.

Parsons, R.F. 1976. Gypsophily in plants --a review. *American Midland Naturalist* 96(1): 1-20.

Peter, G.A. 1897. Hydrophyllaceae. In. A. Engler and K. Prantl, eds.. *Die Naturlichen Pflanzenfamilien* 4(3a): 69.

Peterson, P.M. and O. Morrone. 1997. Allelic variation in the amphitropical disjunct *Lycurus setosus* (Poaceae: Muhlenbergiinae). *Madrono* 44: 427-449.

Peterson, P.M. and J.J. Ortiz-Diaz. 1998. Allelic variation in the amphitropical disjunct *Muhlenbergia torreyi* (Poaceae: Muhlenbergiinae). *Brittonia* 50: 381-391.

Powell, A.M. and B.L. Turner. 1977. Aspects of the plant biology of the gypsum outcrops of the Chihuahuan Desert. In *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico (1974: Sul Ross University)*, ed. R.H. Wauer and D.H. Riskind, 315-325. U.S. Dept. of the Interior, National Park Service: Washington, DC.

Rajakaruna, N. 2004. The edaphic factor in the origin of plant species. *International Geology Review* 46: 471-478.

Rambaut, A. and N.C. Grassly. 1997. Seq-Gen: An application for the Monte Carlo simulation of DNA sequence evolution along phylogenetic trees. *Computer Applications In The Biosciences* 13: 235-238.

Raven, P.H. 1963. Amphitropical relationships in the floras of North and South America. *The Quarterly Review of Biology* 38(2): 151-177.

Roji Garcia, A.P. and J.P. Roji Garcia. 2005. *Por Las Carreteras de Mexico 2006*. Guia Roji, S.A. de C.V:Mexico, D.F.

Ronquist, F. and J.P. Huelsenbeck. 2003. MRBAYES 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* 19: 1572-1574.

Sang, T., D.J. Crawford, and T.F. Stuessy. 1997. Chloroplast DNA phylogeny, reticulate evolution, and biogeography of *Paeonia* (Paeoniaceae). *American Journal of Botany* 84(9): 1120-1136.

Schols, P. and E. Smets. 2001. Carnoy: analysis software for LM, SEM and TEM images. Leuven: distributed by the authors.

Shields, L.M. 1956. Zonation of vegetation within the Tularosa Basin, New Mexico. *The Southwestern Naturalist* 1(2): 49-68.

Shimodaira, H. and M. Hasegawa. 1999. Multiple comparisons of log-likelihoods with applications to phylogenetic inference. *Molecular Biology and Evolution*

16(8): 1114-1116.

Shimodaira, H. and M. Hasegawa. 2001. CONSEL: for assessing the confidence of phylogenetic tree selection. *Bioinformatics* 17(12): 1246-7.

Shimodaira, H. 2002. An approximately unbiased test of phylogenetic tree selection. *Systematic biology* 51(3): 492-508.

Simpson, B.B., J.A. Tate, and A. Weeks. 2005. The biogeography of *Hoffmannseggia* (Leguminosae, Caesalpinioideae, Caesalpinieae): a tale of many travels. *Journal of Biogeography* 32: 15-27.

Small, J.K. 1913. *Flora of the Southeastern United States, 2nd ed.* Published by the author. New York.

Small, J.K. 1933. *Manual of the Southeastern Flora.* Published by the author. New York.

Soltis, D.E. and P.S. Soltis. 1998. Choosing an approach and an appropriate gene for phylogenetic analysis. In *Molecular Systematics of Plants II: DNA Sequencing*, ed. D.E. Soltis, P.S. Soltis, and J.J. Doyle, 1-41. Kluwer Academic Publishers: Boston.

Stamatakis, A. 2006. RAxML-VI-HPC: maximum likelihood-based phylogenetic analyses with thousands of taxa and mixed models. *Bioinformatics* 22(21): 2688-2690.

Stamatakis, A., P. Hoover, and J. Rougemont. 2008. A rapid bootstrap algorithm for the RAxML web servers. *Systematic Biology* 57(5): 758-771.

Steele, K.P. and R. Vilgalys. 1994. Phylogenetic analyses of polemoniaceae using nucleotide sequences of the plastid gene *mat*K. *Systematic Botany* 19(1): 126-142.

Swofford, D L. 2003. PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Sinauer Associates: Sunderland, Massachusetts.

Swofford, D.L., G.J. Olsen, P J Waddell, and D.M. Hillis. 1996. Phylogenetic inference. In *Molecular Systematics*, ed. D.M. Hillis, C. Moritz, and B.K. Mable, 407-514. 2nd ed. Sinauer Associates: Sunderland, Massachusetts.

Taberlet, P., L. Gielly, G. Pautou, and J. Bouvet. 1991. Universal primers for amplification of 3 noncoding regions of chloroplast DNA. *Plant Molecular Biology* 17: 1105-1109.

Thompson, J.D., T.J. Gibson, F. Plewniak, F. Jeanmougin, and D.G. Higgins. 1997. The CLUSTAL_X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic Acids Research* 25: 4876-4882.

Turner, B.L. 1973. *Machaeranthera restiformis* (Asteraceae), a bizarre new gypsophile from northcentral Mexico. *American Journal of Botany* 60(8): 836-838.

Turner, B.L. 2008. *Cryptantha geohintonii* (Boraginaceae), a newly described gypsophile from Nuevo Leon, Mexico. *Phytologia* 90(3): 406-410.

Turner, B.L. and A.M. Powell. 1979. Deserts, gypsum and endemism. In *Arid Land Plant Resources: Proceedings of the International Arid Lands Converence on Plant Resources, Texas Tech University*, ed. J.R. Goodin and David K. Northington, 96-116. International Center for Arid and Semi-Arid Land Studies, Texas Tech University: Lubbock, Texas.

Turner, B.L. and G. Turner. 1983. A new gypsophilic species of *Galium* (Rubiaceae) from North-Central Mexico. *Madrono* 30(1): 31-33.

Tyrl, R.J., F.B. Erteeb, J.L. Bruner, W.L. Ezell, J.R. Estes, and B. Grummer. 1984. A Biosystematic study of the relationship of *Nama hispidum* and *Nama stevensii* (Hydrophyllaceae). *Southwestern Naturalist* 29(4): 367-375.

Vahl, M. 1791. *Symbolae Botanicae [...]* 2:46. Hauniae: Copenhagen, Denmark.

Vargas, P., B.G. Baldwin, and L. Constance. 1998. Nuclear ribosomal DNA evidence for a western North American origin of Hawaiian and South American species of *Sanicula* (Apiaceae). *Proceedings Of The National Academy Of Sciences* 95(1): 235-240.

Verheye, W.H. and T.G. Boyadgiev. 1997. Evaluating the land use potential of gypsiferous soils from field pedogenic characteristics. *Soil Use Management* 13: 97-103.

Ward, D.E. 1983. Chromosome counts from New Mexico and Southern Colorado. *Phytologia* 54: 302-309.

Ward, D.E. 1984. Chromosome counts from Mexico and New Mexico. *Phytologia* 56: 55-60.

Waterfall, U.T. 1946. Observations on the desertg flora of southwestern Texas and adjacent New Mexico. *American Midland Naturalist* 36(2): 456-466.

Weatherby, C.A. 1949. Botanical nomenclature since 1867. *American Journal of Botany* 36(1): 5-7.

Weber, R.H. and F.E. Kottlowski. 1959. Gypsum resources of New Mexico. *Bulletin 68, State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining & Technology, Campus Station, Socorro, New Mexico.* Vol. 68. Socorro, New Mexico.

Welsh, S.L. 1978. Problems in plant endemism on the Colorado Plateau. *Great Basin Naturalist Memoirs* 2: 191-196.

Werle, E., C. Schneider, M. Renner, M. Volker, and W. Fiehn. 1994. Convenient single-step, one tube purification of PCR products for direct sequencing. *Nucleic Acids Research* 22(20): 4354-4355.

Wilgenbusch, J.C., D.L. Warren, and D.L. Swofford. 2004. AWTY: A system for graphical exploration of MCMC convergence in Bayesian phylogenetic inference. http://ceb.csit.fsu.edu/awty.

Wilson, J.S. and J.P. Pitts. 2010. Illuminating the lack of consensus among descriptions of earth history data in the North American deserts: A resource for biologists. *Progress in Physical Geography* 34(4): 419-441.

WRB. 1990. World Reference Base Map of World Soil Resources. Food and Agriculture Organization of the United Nations, Rome. Accessed at: http://www.fao.org/nr/land/sols/soil/wrb-soil-maps/wrb-map-of-world-soil-resources/fr/.

Zwickl, Derrick J. 2006. Genetic algorithm approaches for the phylogenetic analysis of large biological sequence datasets under the maximum likelihood criterion. Ph.D. Dissertation, The University of Texas at Austin. http://garli.googlecode.com.

Vita

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